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Prothoracic gland activity during development of the last instar larva of tobacco cutworm, *Spodoptera litura*

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ABSTRACT: The critical period for PTTH secretion to initiate the ecdysis and changes in the body weight in relation to the size of the prothoracic gland has been observed during the development of the last instar larvae of the tobacco cutworm, *Spodoptera litura*. The prothoracic gland shows four distinct phases in their development and secretion. The maximum activity of the cells occur during 52 and 72 h. The titre of moulting hormone, ecdysone in the hemolymph was determined by radioimmunoassay and correlated with the level of activity of the cells.
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KEYWORDS: *Spodoptera litura*, prothoracic gland, PTTH, ecdysone

INTRODUCTION

It is now well known that the changes in the moulting hormone titre in the blood of numerous insects reflect variations of prothoracic gland activity and modification in the rate of hormone metabolism (Smith, 1985; Koolman and Karlson, 1985). Studies on the ultra structure of the gland and changes in ecdysteroid titers in the course of metamorphosis of the *Manduca sexta* (Sedlak *et al.*, 1983) and the *Locusta migratoria* (Hirn *et al.*, 1979) have shown a positive correlation between secretory activity and development of the prothoracic gland. *In vivo* study of the prothoracic gland of *Manduca* in the last-larval stadium showed that two peaks of glandular activity were temporally correlated with two peaks of PTTH release (Truman and Riddiford, 1974; Bollenbacher *et al.*, 1975) suggesting that PTTH is probably directly affecting gland activity and the gated release of PTTH was confirmed by induction of the prodromal signs of pupation of *Manduca* (Truman and Riddiford, 1974). A temporal organization of secretion of PTTH by the brain and ecdysone by the prothoracic gland, responsible

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for the induction of the prodrome of pupation including gut purge has been reported in *Samia cynthia ricini* (Fujishita and Ishizaki, 1982). This is followed by a second higher level of ecdysone secretion by the prothoracic glands leading to apolysis of the epidermis from the cuticle and subsequent secretion of new cuticle, culminating in shedding or ecdysis of the old cuticle.

Few studies have been reported on the cyclical changes in the prothoracic gland activity in relation to its structure and the release of PTTH during metamorphosis in *Spodoptera littoralis* (Zimowska *et al.*, 1985). The action of PTTH on the changes and secretion of prothoracic gland in fifth larval instar of *Spodoptera litura* have been reported (Karaiyan *et al.*, 2002). In the present study correlation of changes in the prothoracic glands of the last-instar larvae of *Spodoptera litura* with larval weight, behaviour, hemolymph ecdysteroid titer and the time of requirement for complete pupation are reported.

MATERIALS AND METHODS

Insect rearing

Tobacco cutworms, *Spodoptera litura* were reared on the leaves of *Ricinus communis* under 12 L : 12 D photoregime at 29 ± 1 °C. The insect passes six larval instars to become pupa and moth. The freshly molted sixth instar larvae were kept in plastic containers. Under these conditions all larvae which ecdysed to last-instar (sixth) at night stopped feeding after 48 h during 57 to 60 h of its larval period on third night from its last larval molt and pupated during 96–108 h on fifth night. These larvae which began metamorphosis during the third night were used for all experiments.

Staging, weighing and ligation of last-instar larvae

Fifth instar larvae with slipped head-capsules were separated and its molting to the last instar was observed. Ecdysis occurred in early scotophase. Larvae were usually observed to ecdyse in groups and selected in hourly intervals. Freshly ecdysed larvae were timed according to the hour of ecdysis, maintained in groups of 10 and weighted at various hourly intervals. Animals were neck-ligated between 15 and 81 h at 3 h intervals using black polyster yarn (Heritage, USA) and the per cent of pupation was determined. The ligated larvae were maintained clean and free of moisture from oozing of gut content. Heads were removed after ligation and the ligated area was treated with alcohol.

Morphological studies of the prothoracic gland

Freshly molted last-instar larvae were dissected at various ages in *Bombyx* saline (Okuda *et al.*, 1985). The size and number of dissected prothoracic glands cells were measured using in ocular micrometer, the cytological changes were photographed.

Radioimmunoassay of ecdysteroid from hemolymph of last-instar larvae

Radioimmunoassay of ecdysteroids was carried out by the method of Borst and O'Connor (1982). Ten microliters of hemolymph was collected into a glass microliter pipette from various ages of last-instar larvae by cutting off a proleg. Hemolymph was vortexed in 500 μl of the ice-cold 75% methanol and stored at $-20\,^{\circ}C$ at least over night. Precipitated hemolymph was briefly vortexed to break apart particulates, centrifuged at 3000 g, 4 °C for 20 minutes and the supernatant collected was dried under low pressure for ecdysteroid analysis.

The antibody was a gift from W. E. Bollenbacher University of North Carolina, Chapel Hill, its affinity for various ecdysteroids has been characterized (Gilbert *et al.*, 1977). The ratio of the mass of 20-hydroxyecdysone required to displace 50% of the labeled ecdysone compared to the mass of the labeled ecdysone was 2.8 (23, 24 4-^{3}H (N)-ecdysone, 60–80 Ci/mmol, NEN Research products, Boston, Massachusetts USA), ecdysone and 20-hydroxyecdysone were purchased from Sigma Chemical Co., St. Louis, Missouri, USA).

RESULTS

Growth of the prothoracic gland during the 6th larval instar

Each prothoracic gland was found to be relatively compact and trilobed consisting of approximately 40–60 polyploid cells, depending on age. The gland cells of freshly molted last-instar larvae were small (4.72×10^{-3} mm^2) and rather round. During the first 24 h of the feeding period (at the initiation of feeding) none of the prothoracic gland cells showed any sign of secretory activity. After 36 h of feeding, the prothoracic gland cells became larger (7.96×10^{-3} mm^2) and ovoid in shape. On the second day further growth of the gland cells was observed, initially among the terminal cells. At the end of the second day (shortly before the cessation of feeding) the size of the cells reached 9.31×10^{-3} mm^2. The nuclei became lobulated and the cytoploasm was more homogeneous with distinctly lighter regions limited to the area adjacent to the cell membranes.

Around midnight at the end of the phagoperiod (48 h) all the prothoracic gland cells increased in size to about 9.75×10^{-3} mm^2. After gut purge (60 h), the prothoracic gland cells decreased in size to 8.48×10^{-3} mm^2. At the end of the third day all the prothoracic gland cells became highly active, as determined by their size (11.25×10^{-3} mm^2). All the larvae ligated at this time pupated in less that 1.5 days (Fig. 2). At this time larvae completed construction of their cocoons. Larval–pupal ecdysis occurred at the end of the fourth day and during the fifth night. Prothoracic gland cell size remained quite large (9.87×10^{-3} mm^2) a few hours before the larval–pupal ecdysis (Figs 1 and 4).

Critical period of PTTH secretion

Larvae were neck-ligated at various times after the last-instar larval molt and the headless were maintained for pupal cuticle development observation. Larvae

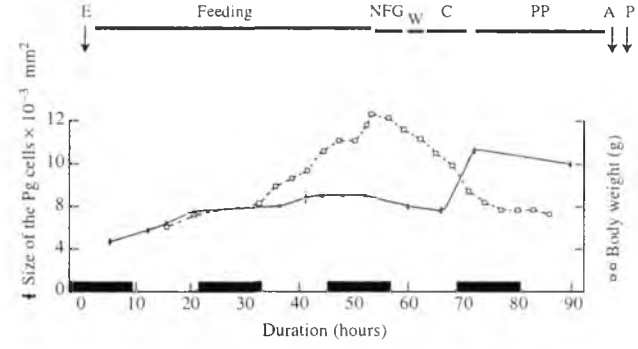

FIGURE 1. Changes in the size of the prothoracic glands and weight gain in last-instar larva of *Spodoptera litura*.
E-Ecdysis, NF-Non feeding, G-Gut purge, W-Wandering, C-Cocoon, PP-Prepupal, A-Apolysis and P-Pupal stages.

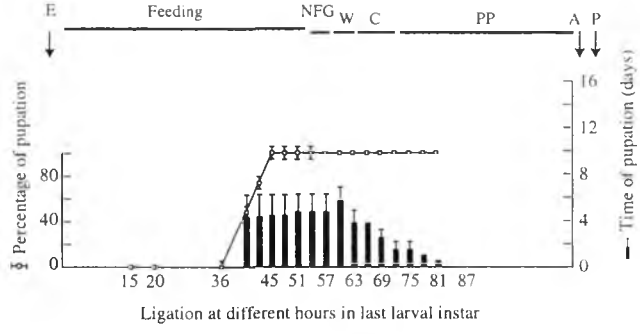

FIGURE 2. Head-critical period for PTTH secretion of last-instar larvae of *Spodoptera litura* for pupation

neck-ligated within 24 h after the last-instar larval molt died without initiating metamorphosis (Fig. 2). Neck-ligation performed 24–39 h after the last-instar larval molt survived 7 to 10 days and formed larval-pupal intermediates that failed to ecdyse. Larval characters were retained in the anterior region and pupal cuticle synthesis was initiated in the posterior region (mosaic form). For the larvae neck-ligated 6 h before the end of the second day at 42 h, 50% of the larvae were able to synthesize a complete pupal cuticle and pupate within 9–10 days. The rest were observed to be larval-pupal intermediates.

Unlike the previous instances, larvae neck-ligated from 45 to 81 h resulted in 100% pupation (Fig. 2). The larvae neck-ligated between the non-feeding stage to 3 h before prepupation, pupated with a delay of 1–2.5 days as compared to normal pupae. For larvae neck-ligated from the end of the 3rd day onward, pupation was completed in

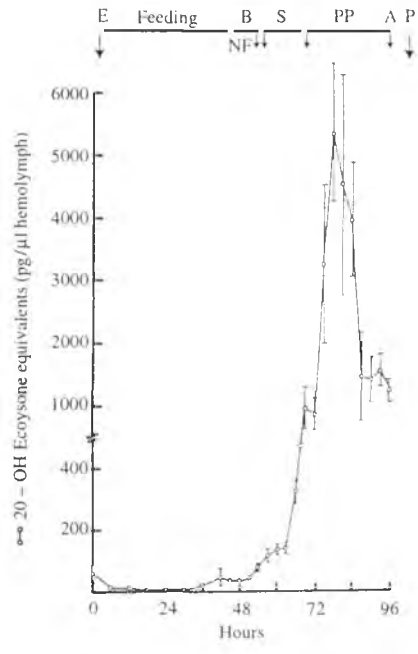

FIGURE 3. Haemolymph ecdysteroid level in different stages of last larvae of *Spodoptera litura*

the normal time. It is likely that some PTTH from the brain was released by 24 h and that enough PTTH was obtained from the brain at 45 h to allow complete pupation.

Hemolymph ecdysteroid titers

Hemolymph ecdysteroid titers were determined (Fig. 3) to correlate their changes with prothoracic gland development and with the ability to complete pupation in the absence of the head. Hemolymph ecdysteroid titers were nearly undetectable up to 33 h, then increased to a sustained low level from 38–71 h correlating with a plateau in prothoracic gland cells size (Fig. 1). Following 72 h, the hemolymph titer increased dramatically, correlating with a 2nd increase in prothoracic gland cell size. The 38–71 h period also correlated with the ability to complete pupation in the absence of the head, although with a delay of 5–8 days, and the hemolymph ecdysteroid titer increase following 72 h correlated with the ability of headless larvae to complete pupation in near normal time (Figs 2 and 3).

DISCUSSION

The molting process of the insect during different larval instars are under the control of brain which in turn control the secretion of ecdysteroid, molting hormone which is synthesized and secreted by prothoracic gland. In *S. litura* it is a trilobed structure

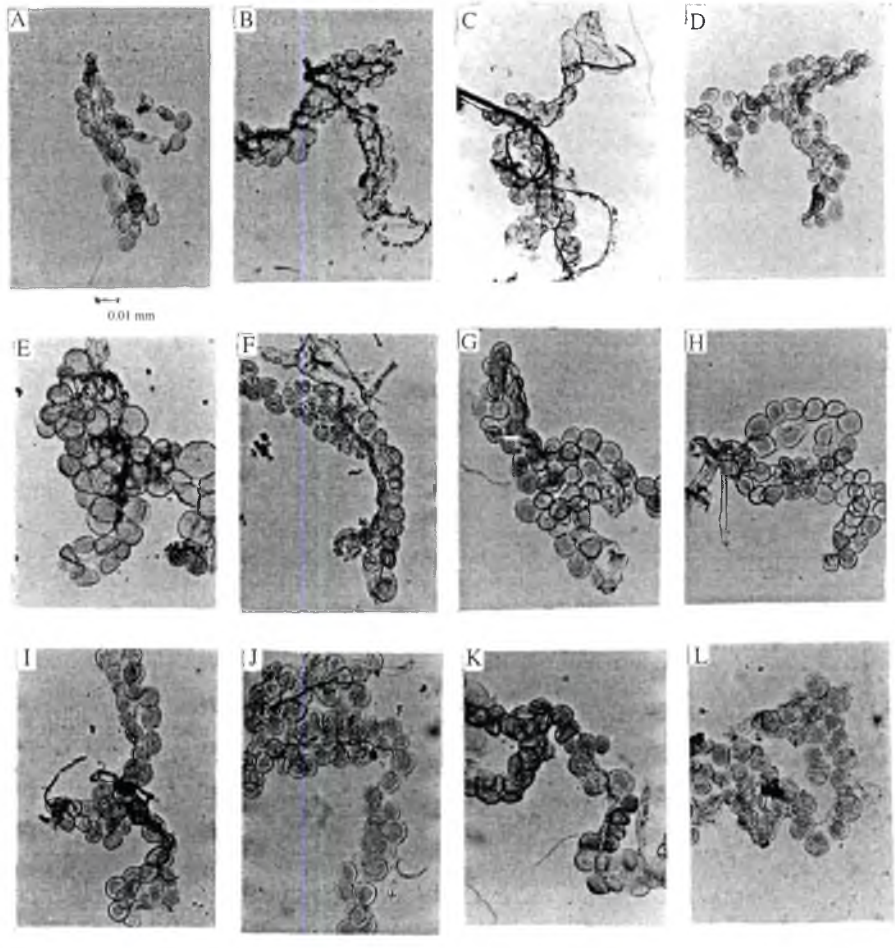

FIGURE 4. Morphological changes in the prothoracic gland during different stages of last-instar larva and pupal of *Spodoptera litura*. Feeding: A-0-5 h, B-12 h, C-20 h, D-41 h. Non-feeding: E-52 h, F-60 h, Spinning: G-66 h. Prepupal: H-72 h, I-78 h, J-84 h, K-90 h, L-94 h.

consisting of cells which undergo changes in size, activity and secretion during different stages such as feeding, non-feeding and prepupal stages of the larvae. It shows four different phases such as inactive, growth, synthetic and release phase. The inactive phase occur from soon after molting to early feeding period of the larvae. During growth phase the cells enlarge and divide without any secretory activity. In late feeding period the cells become large in size with deep peripheral channels, distinct boundaries, accumulation of granular inclusions. The gland cells during non-feeding stages releases its content and cells decrease in size. Such studies on *S. littoralis* (Zimowska *et al.*, 1985) supports this finding.

Brain of insects are the sources of prothoracicotropic hormone, which is secreted and released at specific stages of the larval period under the control of photoregime, larval age and larval weight. Neck-ligated larvae during feeding period resulted in larval–pupal intermediates due to the insufficient secretion of hormone to induce prothoracic gland to secrete sufficient molting hormone. In *S. litura*, the first release probably occurs at the beginning of the second day of feeding after 24 h, since larvae ligated after this time resulted in pupal cuticle formation in the abdominal region only. A second large release of PTTH probably occurs prior to the end of the second day (i.e. before 45 h), as evidenced by complete pupation in larvae ligated after this time. This result suggests that the prothoracic glands are sufficiently activated by PTTH by 45 h to synthesize enough ecdysone to form pupal cuticle throughout the insect, although an extended release of PTTH is implied, possible up to 72 h, since it is after this time that pupation commences in the normal time, even in the absence of the head.

The first peak of PTTH secretion in *S. litura* presumably initiates the secretion of ecdysone in the prothoracic gland, and this is able to initiate the induction of the prodromal signs of pupation and the effects of non-feeding, gut purge, wandering, spinning and contraction of the larval body. The complete pupation that results when ligated at the later stages of the last-instar larvae is presumably due to the release of a higher titer of ecdysone by the second induction of PTTH release in later stages. The *S. litura* appears similar to other spices of Lepidoptera in terms synthesis, action and time of release of the hormonal and neurohormonal factors that regulate metamorphosis.

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Prey preference and predatory potential of spiders in cotton ecosystem

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ABSTRACT: Prey preference and predatory potential of four major species of spiders occurring in cotton plantations *viz.*, *Peucetia viridana* Stoliczka, *Argiope catenulata* Doleschall, *Oxyopes javanus* Thorell and *Neoscona theisi* Walcknear were studied under laboratory conditions. The order of preference showed by spiders was aphid, whitefly, leafhopper and caterpillars. The predatory potential was maximum for *P. viridana* followed by *A. catenulata*, *O. javanus* and *N. theisi*. Between the sexes, females were more efficient predators. © 2003 Association for Advancement of Entomology

KEYWORDS: prey preference, predatory potential, spiders on cotton

INTRODUCTION

In cotton ecosystem, spiders are the most familiar, efficient and ubiquitous obligate predator, which feed on different types of prey. Spiders have no discriminatory reaction and consume whatever prey is offered. However, spiders do have preference when different preys were available as indicated by disagreeable odours and tastes which cause them to reject many of the potential preys. Qualitative analysis of the food of spiders showed that they like soft bodied, immature stages with more internal body fluid, especially the homopteran insects (Baldev Prashad, 1985). In the present experiment, prey preference and predatory potential of four major species of spiders available in cotton ecosystem *viz.*, *Peucetia viridana* Stoliczka, *Argiope catenulata* Doleschall, *Oxyopes javanus* Thorell and *Neoscona theisi* Walcknear were studied.

MATERIALS AND METHODS

Prey preference of spiders

With a view to determine the host preference of the spiders, ten nymphs of preys insects like *Aphis gossypii* Glov., *Bemisia tabaci* Genn., *Amrasca devastans* Dist.,

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TABLE 1. Prey preference of spiders to mixed pests population of cotton

Spider species	* Mean predation (%) per day			Mean
	A. gossypii	*B. tabaci*	*A. devastans*	
P. viridana	36.0 (36.84)	29.0 (32.54)	24.0 (29.27)	29.6 (32.88)^a
A. catenulata	24.0 (29.27)	22.0 (27.94)	18.0 (25.05)	21.3 (27.42)^b
O. javanus	19.0 (25.74)	17.0 (24.30)	17.0 (24.11)	17.6 (24.72)^c
N. theisi	14.0 (21.80)	13.0 (21.05)	14.0 (21.80)	13.6 (21.55)^d
Mean	23.2 (28.41)^a	20.2 (26.46)^b	18.2 (25.06)^c	

*Mean of seven observations. In a row and column means followed by same letter are not significantly different by DMRT ($P = 0.05$); Figures in parenthesis are Arc sin $\sqrt{P}$; where P is percent predation per day.

neonate larvae of *Heliothis armigera* Hub. and *Spodoptera litura* Fab. were released together along with one species of spider on five week old potted cotton plants and covered with mylar film. The experiment was conducted in completely randomized block design with five replications for each spider species. The number of insects predated were recorded 24 h after their release and continued up to 7 days. The population of prey (10 each) and predator (1) was maintained daily after each observation. The percent prey predation was worked out.

Predatory potential of spiders

The predatory potential of *P. viridana*, *A. catenulata*, *O. javanus* and *N. theisi* adults was studied following the method of Kamal *et al.* (1992). The adults were starved for 24 h before the start of the experiment and then caged individually with ten nymphs of preys like *A. gossypii*, *A. devastans* and *B. tabaci*, neonate larvae of *H. armigera* and *S. litura* along with one species of the above said spiders. The experiment was conducted in completely randomized block design with five replications for both sexes separately. The mortality of prey insects were recorded 24 h after their release and continued upto 5 days.

RESULTS AND DISCUSSION

Among the preys of spiders tested in cotton ecosystem, *P. viridana* showed highest preference to *A. gossypii* (36.0%) followed by *B. tabaci* (29.0%) and *A. devastans* (24.0%). The similar preference was also exhibited by *A. catenulata*, *O. javanus* and *N. theisi*. However, the extent of predation was less; 24.0, 22.0 and 18.0 per cent by

TABLE 2. Predatory potential of spiders on sap feeders on cotton

Spiders	* Mean consumption per day					
	A. devastans	Mean	*A. gossypii*	Mean	*B. tabaci*	Mean
P. viridana						
Male	4.2 (2.18)	5.4	6.2 (2.61)	7.3	6.0 (2.56)	7.0
Female	6.6 (2.68)		8.3 (2.97)		8.0 (2.92)	
A. catenulata						
Male	3.2 (1.98)	4.4	6.2 (2.61)	7.5	6.2 (2.60)	7.2
Female	5.6 (2.48)		8.8 (3.06)		8.2 (2.96)	
O. javanus						
Male	3.4 (1.98)	4.4	6.4 (2.64)	8.0	6.0 (2.56)	7.2
Female	5.4 (2.44)		9.6 (3.18)		8.4 (2.99)	
N. theisi						
Male	3.5 (2.00)	3.9	5.2 (2.40)	6.4	5.9 (2.54)	7.2
Female	4.4 (2.22)		7.6 (2.86)		8.5 (3.00)	
Interactions						
Sexes × Spiders						
SED	0.0318		0.0417		0.0491	
CD	0.0650		0.0853		0.1002	
Sexes × Spiders						
SED	0.0201		0.0264		0.0310	
CD	0.0411		0.0539		0.0634	
Species × Spiders × Sexes						
SED	0.0450		0.0590		0.0694	
CD	0.0919		0.1206		0.1418	

*Means of five observations. Figures in parenthesis are $\sqrt{x}$ transformed values; where x is numbers/day.

A. catenulata; 19.0, 17.0 and 17.0 per cent by *O. javanus* and 14.0, 13.0 and 14.0 percent by *N. theisi* respectively (Table 1).

The predatory potential of *P. viridana* was the highest of all spiders tested followed by *A. catenulata*, *O. javanus* and *N. theisi*. The extent of predation by *P. viridana* was 5.4 *A. devastans*, 7.3 *A. gossypii*, 7.0 *B. tabaci*, 3.9 *Spodoptera* and 4.1 *Helicoverpa*

TABLE 3. Predatory potential of spiders on *Helicoverpa* and *Spodoptera* on cotton

Spiders	* Mean consumption per day (Neonate larvae/day)			
	H. armigera	Mean	*S. litura*	Mean
P. viridana	3.3		3.5	
Male	(1.96)	3.9	(2.01)	4.1
Female	4.4		4.7	
	(2.23)		(2.29)	
A. catenulata				
Male	3.4		3.7	
	(1.97)	4.1	(2.05)	4.4
Female	4.8		5.1	
	(2.31)		(2.38)	
O. javanus				
Male	3.2		3.8	
	(1.95)	4.1	(2.09)	4.5
Female	5.0		5.2	
	(2.34		(2.45)	
N. theisi				
Male	3.7		3.4	
	(2.05)	4.3	(1.99)	4.0
Female	5.0		4.6	
	(2.35)		(2.32)	
Interactions				
Sexes × Spiders				
SED	0.0421		0.0307	
CD	0.0859		0.0627	
Sexes × Spiders				
SED	0.0266		0.0794	
CD	0.0543		0.0396	
Species × Spiders × Sexes				
SED	0.05955		0.0434	
CD	0.121		0.0886	

* Means of five observations. Figures in parenthesis are $\sqrt{x}$ transformed values; where x is numbers/day.

per day and this was followed by *A. catenulata* (4.4, 7.5, 7.2, 4.1 and 4.4); *O. javanus* (4.4, 8.0, 7.2, 4.1 and 4.5) and *N. theisi* (3.9, 6.4, 7.2, 4.3 and 4.0) of respective preys. Between the sexes, the predatory potential of female was more than male; extent of 1.5, 1.4, 1.3, 1.5 and 1.3 times in *P. viridana*, 1.7, 1.4, 1.3, 1.4 and 1.3 times in *A. catenulata*, 1.4, 1.3, 1.3, 1.3 and 1.3 times in *O. javanus* and 1.2, 1.4, 1.4, 1.3 and 1.3 times in *N. theisi* on respective preys *viz.*, *A. devastans*, *A. gossypii*, *B. tabaci*, *Spodoptera* and *Helicoverpa* (Tables 2 and 3).

The spiders in cotton *viz.*, *P. viridana*, *A. catenulata*, *O. javanus* and *N. theisi* showed highest preference to *A. gossypii* than *B. tabaci* and *A. devastans*. This is in conformity with findings of Alerweireldt (1994) that aphididae can make 55 percent of spider prey in cotton. Irrespective of spiders habits, whether hunters (*P. viridana* and *O. javanus*) or web spinners (*A. catenulata* and *N. theisi*), they preferred *A. gossypii* as major food followed by *B. tabaci* and *A. devastans* in cotton. However Nyffler *et al.* (1987) reported that *P. viridana* preferred *A. devastans* to *A. gossypii*. Vanitha (2000) also reported that web spiders *viz.*, *Arigiope pulchella* Tikader and *Leucage decorata* Blackwall preferred more of *A. devastans* followed by *B. tabaci*. The differences in the prey preference can be attributed to the habitat of spiders. *O. javanus* moves all over the plant and search for the prey whereas *P. viridana* waits on the surface of leaf in cryptic manner and feeds on prey whenever encountered. The web spinners can consume only those insects that got trapped in web.

The predatory potential studies in cotton indicated that the spiders were consuming *A. gossypii*, *A. devastans*, *B. tabaci* and neonate larvae of *H. armigera* and *S. litura* as food in the ascending order of preference. When the consumption rate on sucking pest complex was compared with that of lepidopterans (caterpillars), all the spiders preferred most of sucking pests as major food source to lepidopterans. This corroborates the statement of Turnbull (1960), who stated that the lepidopterans and coleopterans often escape from fragile sheet webs and thus compose an insignificant fraction of the spider diet. Female spiders are reported to have the ability to store large amount of fats (Collatz and Mommsen, 1975) as reserve food and fat was the main source of energy for embryonic development (Palanichamy and Pandian, 1983). This might be the plausible reason for more consumption in the present study. The predatory potential of spiders in cotton on sucking pests was high in *P. viridana* followed in *A. catenulata*, *O. javanus* and in *N. theisi*. However, Vanitha (2000) observed that *O. javanus* was the efficient spider predator than any other species in cotton.

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Descriptions of three new species of Encyrtidae (Hymenoptera: Chalcidoidea) from India

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ABSTRACT: Three new species of Encyrtidae, two belonging to the genus *Cerchysiella* Girault and one to *Trichomasthus* Thomson, are described from India.
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KEYWORDS: Indian Encyrtidae, Hymenoptera, new species in *Cerchysiella* and *Trichomasthus*

INTRODUCTION

This paper is based on a small collection of encyrtids (Hymenoptera: Encyrtidae) made by one of us (M.C. Basha). It deals with the descriptions of two new species in the genus *Cerchysiella* Girault and one new species in *Trichomasthus* Thomson. These genera can be identified with the help of the key to Indo-Pacific genera given by Noyes and Hayat (1984). The types of the new species are in the Zoology Department, A.M.U., Aligarh.

Genus *Cerchysiella* Girault

The genus is cosmopolitan in distribution, containing 21 species. From India only two species are known: *C. kamathi* (Mani and Saraswat, 1974), and *C. latiscapa* (Shafee and Fatma, 1984). We describe here two new species. Because of the presence of several other apparently undescribed species in India, which are under study by the first author, it is not considered necessary to provide a key to species at this stage. However, the new species are distinguished from related species under these species.

Cerchysiella meghaiana sp. nov. (Figs 1–3)

Female. Body completely dark brown to blackish; frontovertex bluish-green; mesoscutum dark violet with some bronzy tinge; gaster mainly violet with some

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bronzy shine. Antenna completely dark brown to black. Wings hyaline. Legs with all coxae, hind femur and tibia dark brown; fore femur brown except pale base and apical third; fore tibia pale brown with both ends paler; mid femur and tibia largely pale yellow with an indefinite pale brownish infuscation; tarsi pale yellow.

Frontovertex with shallow reticulate sculpture which becomes transversely elongate in front of anterior ocellus, and with small setigerous punctures; mesoscutum with raised reticulate sculpture, deeper than on frontovertex; scutellum smooth throughout; propodeum medially with some longitudinal carinae of which the median carina is complete. Eyes setose, setae pale brown and each about 2× as long as a facet; setae on frontovertex fine and long, slightly longer than diameter of anterior ocellus; other setae on head and thoracic dorsum pale brown; scutellum with 12 pairs of setae; sides of propodeum with white setae.

Head, in front view, about 2.5× as broad as frontovertex width, and about one-seventh broader than high. Antenna as in Fig. 2; scape convexly expanded, 3× as long as broad; pedicel longer than F1 and F2 combined, and F1 smaller and shorter than F2. Scutellum smooth, without sculpture. Ovipositor shorter than mid tibia; third valvula shorter than mid tibial spur. Both wings distorted in distal halves, otherwise venation and setation as in Fig. 3. Mandible as in Fig. 1.

Relative measurements (From slide): Frontovertex width, 21; scape length, 23. Thorax length, 75; mesoscutum length (width) 30 (48); scutellum length (width) 29 (33); propodeum length, 4. Gaster length, 81; ovipositor length, 38; third valvula length, 8.5; TVII length, 47. [Mid tibia length, 47; mid basitarsus length, 11; mid spur length, 15].

Male. Unknown.

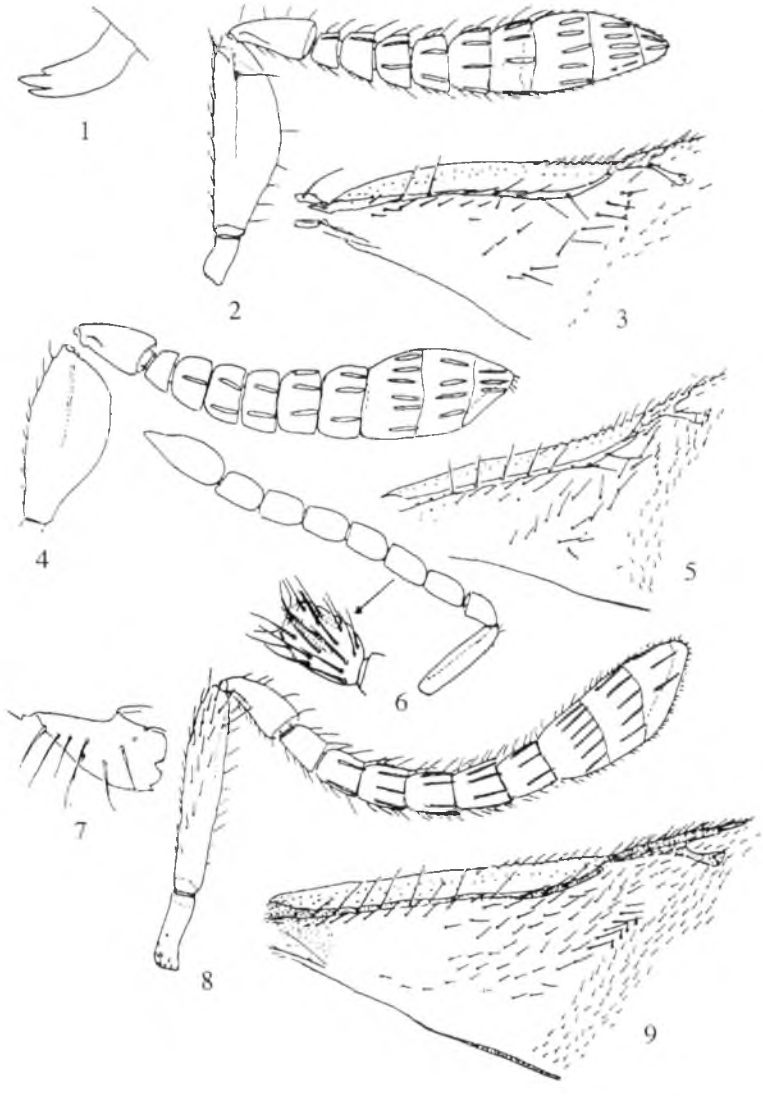
HOLOTYPE, ♀ (on slide under 4 coverslips, slide No. EH. 967): India: Meghalaya, Shillong, 13.xi.1989 (M.C. Basha).

Comments. *Cerchysiella meghaiana* sp. nov. can be separated from all the described species of the genus, including the two species known so far from India [*latiscapa* (Shafee and Fatma), *kamathi* (Mani and Saraswat)] and the new species described below, by the following combination of characters: Scape evenly expanded, 3× as long as broad; pedicel longer than F1 and F2 combined; F1 shorter and smaller than F2; smooth scutellum; shorter ovipositor which is shorter than mid tibia or length of last tergite of gaster; and shorter third valvula which is shorter than mid tibial spur.

ETYMOLOGY. The specific name is derived from Meghalaya, abbreviated to 'Megha' + ian [Neo Latin], a variant of the Latin suffix, -an, meaning 'connected with' or 'belonging to'.

***Cerchysiella harliga* sp. nov. (Figs 4 and 5)**

Female. Length, thorax + gaster, 1.15 mm. Resembles *meghaiana* sp. nov. in colour and sculpture except as noted below; legs, including all coxae, dark brown



FIGURES 1–9. (1–3) *Cerchysiella meghaiana* sp. nov., female: 1, mandible; 2, antenna; 3, fore wing, basal part. (4, 5) *Cerchysiella harliga* sp. nov., female: 4, antenna; 5, fore wing, basal part. (6–9) *Trichomasthus assamensis* sp. nov.: 6, antenna, male; 7, mandible, female; 8, antenna, female; 9, fore wing, basal part, female.

except as follows: distal third of fore tibia; mid tibia completely except for some brownish infuscation in basal third; tarsal segments 1–5 of fore and hind tarsi, and 1–4 of mid tarsus, pale yellowish.

Setae on frontovertex fine, but at least slightly longer than diameter of anterior ocellus; setae on mesoscutum and scutellum appear translucent in balsam; scutellum with 20 pairs of setae; eyes setose, setae pale brown and each about 2× as long as a facet.

Antenna as in Fig. 4; basal part of fore wing as in Fig. 5. Other details as given in the relative measurements.

Relative measurements (From slide): Head frontal width (length), 49 (42.5): frontovertex width, 23 (scape length, 20); eye length, 28; malar space length, 14. Mesoscutum length (width), 29 (46); scutellum length (width), 30 (33); propodeum length, 4. Fore wing length (width) 122 (51). Mid tibia length, 44; mid basitarsus length, 13.5; mid spur length, 14. Ovipositor length, 37; third valvula length, 9; TVII length, 50.

Male. Unknown

HOLOTYPE, ♀ (on slide under 4 coverslips; slide No. EH.1007): India: Uttar Pradesh, Aligarh, 18.i.1989 (M.C. Basha).

Comments. *C. harliga* sp. nov. is apparently very closely related to *latiscapa* (Shafee and Fatma, 1984), but differs as follows: Funicle segments dark brown and relatively more transverse; fore wing proximad of the linea calva with one complete line and a second incomplete line of setae; setae behind parastigma more numerous and arranged in about two lines; setae on mesoscutum and scutellum translucent in balsam. [In *latiscapa*; Funicle segments relatively less transverse, and F1 or F1 and F2 at least partly yellowish brown; fore wing proximad of the linea calva at most with one complete line of setae, incomplete in the holotype; and with a single line of setae behind parastigma.

ETYMOLOGY. The species name is an anagram of 'Aligarh'.

Genus *Trichomasthus* Thomson

This genus is cosmopolitan in distribution, containing nearly 50 described species, but only two species are known from India: *T. rufus* (Singh *et al.*, 1991) and *T. solitocornis* (Kaul and Agarwal, 1986).

***Trichomasthus assamensis* sp. nov. (Figs 6–9)**

Female. Length, 1.30–1.42 mm. (Holotype, 1.32 mm). Body dark brown; frontovertex and face dull bluish-green, setigerous puncts bronzy; thoracic dorsum dark, bronzy-violet; scutellum bronzy-violet with sides and apex bluish-green; gaster intense bronzy, with TI shining bluish-green; visible part of third valvulae testaceous. Radicle dark brown; scape, pedicel and flagellum testaceous to brownish-yellow. Wings hyaline; submarginal vein basally and marginal vein dark brown. Legs with all coxae dark brown; rest of leg parts testaceous with pale brownish suffusions, without distinct dark brown areas; tarsi brownish yellow, last two segments brown.

Frontovertex with slightly raised reticulate sculpture, the cells smaller than punctures; setigerous punctures distinct, irregularly arranged in ocellar area, and in four lines in front of anterior ocellus apart from a line along each eye margin; malar space with elongate-reticulate sculpture; pronotum and mesoscutum with fine, reticulate sculpture which is shallower than that on frontovertex, and mesoscutum with minute setigerous punctures; sculpture on scutellum about same as on mesoscutum or slightly more deeper, but with sides and apex narrowly smooth; sides of propodeum with white setae. Setae on head and thorax brown to dark brown; eyes setose, setae transparent, but each clearly longer than a facet.

Frontovertex width slightly less than one-third of head width; occipital margin sharp and eyes slightly over-reaching occiput behind; ocellar triangle with apical angle a right angle (90°); posterior ocelli less than half the diameter of an ocellus to eye margin, and less than one diameter to occipital margin; scrobes distinct, facial impression inverted 'U'-shaped with rounded margins; interscrobal area elongate, convex. Thoracic dorsum with scutellum overlapping propodeum medially. Mandible as in Fig. 7. Antenna as in Fig. 8. Basal part of fore wing as in Fig. 9.

Relative measurements (From Holotype): head dorsal width, 40; frontovertex width, 13; eye length, 26; malar space length, 13; distance between posterior ocelli, 7; distance between a posterior ocellus to occipital margin, 2.5. Thorax length, 48; mesoscutum length (width), 21 (40); scutellum length (width), 22 (24). Gaster length, 41. (From slide): Fore wing length (width), 157 (69); hind wing length (width), 112 (30); marginal fringe length, 5. Mid tibia length, 68; mid basitarsus length, 21; mid spur length, 21. Ovipositor length, 73.5; third valvula length, 25.5; TVII length, 58.

Male. Length, 1.10 mm. Similar to female in colour, sculpture and other details, except as follows: Radicle, scape largely (except distally), and pedicel brown; flagellum brownish yellow to testaceous. Legs same as in female, but basal half of fore femur, and tibia except distal half or so, brownish, but paler than coxae; hind femur brown.

Structurally similar to female except for the slightly broader frontovertex; ocellar triangle with apical angle slightly obtuse; toruli removed form mouth margin by more than their own lengths and with their upper margins very slightly above lower eye margins. Antenna as in Fig. 6.

Relative measurements (Slide): Head frontal width (length) 57 (51); frontovertex width, 22 (scape length, 18); eye length, 33; malar space length, 19; torulus length, 6.5; torulus-mouth margin distance, 10; inter-torular distance, 12.

HOLOTYPE, ♀ India: Assam, Guwahati, 5–7.xi.1989, ex indet. coccids (M. Basha)

PARATYPES: 13 ♀, 5 ♂ (2 ♀, 1 ♂, on two slides, EH.1008 and EH.1009), same data as holotype.

Comments. *T. assamensis* sp. nov. is apparently very close to the Indian species, *T. rufus* (Singh *et al.*, 1991) and the Russian species, *T. dignus* Khlopunov (1987) (see Hayat, 1999; Trjapitzin, 1989), but differs by the following combination of characters: funicle with all segments slightly longer than broad and very slightly and gradually broadened distally, and distal segments very slightly longer than F1; F1 clearly shorter than pedicel; clava about as long as F3-6 combined and rather strongly obliquely truncate at apex; fore wing (disc with a distinct triangular bare area at base) with marginal vein longer (more than 1.5×) than stigmal vein [In *rufus* and *dignus*: basal 2–3 funicle segments narrower than F6; F1 at least 2× as long as broad and very slightly shorter (*rufus*) to longer (*dignus*) than pedicel; clava shorter than F4-6 combined; fore wing with marginal vein shorter (*dignus*) than or at most as long as (*rufus*) stigmal vein.]. Additionally, *rufus* has the fore wing disc setose to base with a very small bare area at base, and costal cell broad in basal two-thirds and abruptly narrowed towards apex. The new species also differs from the other Indian species, *T. solitocornis* (Kaul and Agarwal, 1986) (see Hayat, 1989) in the above characters and also in having the fore wing hyaline, but in *solitocornis* the fore wing has a curved infuscate subapical band.

ETYMOLOGY. The specific name is derived from the name of the Indian State from which the specimens were collected.

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Description of a new species of *Cybocephalus* Erichson (Coleoptera: Cybocephalidae) from India feeding on the spiralling whitefly, with notes on its biology

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ABSTRACT: *Cybocephalus indicus* Tian & Ramani, n. sp. (Coleoptera: Cybocephalidae), a predator of the spiralling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae), a recently introduced pest, is described from Bangalore, India. Notes on its biology and feeding potential are given.
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KEYWORDS: *Cybocephalus indicus* n. sp., *Aleurodicus dispersus*, biology, India

INTRODUCTION

Species belonging to the genus *Cybocephalus* Erichson are known to be generally predaceous on diaspidid scale insects (Homoptera: Diaspididae) throughout the tropical, subtropical and temperate regions of the world (Vinson, 1959; Endrödy-Younga, 1968; Blumberg and Swirski, 1974; Wang *et al.*, 1984) and several species have been used in colonization attempts to control armoured scales (Balachowsky, 1925; Rosen and DeBach, 1978). Despite reports that species of *Cybocephalus* are sometimes found in proximity to whiteflies (Kartman, 1946), very few have been recorded feeding on whiteflies in the field. Among the few are *C. aleyrodiphagus* Kirejtshuk, James and Heffer on *Orchamoplatus citri* (Takahashi) (Homoptera: Aleyrodidae) in Australia (Kirejtshuk *et al.*, 1997), and unidentified species on *Trialeurodes ricini* (Misra) (Chandra and Avasthy, 1978) and *Neomaskellia bergii* Signoret (Kapadia and Puri,

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1993) in India. Indeterminate species of *Cybocephalus* feeding on the spiralling whitefly, *Aleurodicus dispersus* Russell have been recorded in Indonesia (Kajita *et al.*, 1991) and Minicoy, India (Ramani, 2000). *A. dispersus* was first reported in 1993 from Kerala (Palaniswami *et al.*, 1995) and later from other parts of peninsular India and the Lakshadweep islands. A new species of *Cybocephalus* found feeding on the eggs and nymphs of *A. dispersus* during surveys for the natural enemies of the pest in and around Bangalore is described with brief notes on its biology.

***Cybocephalus indicus* Tian & Ramani, sp. nov. (Figs. 1–7)**

Length (not including the bent head): 1.05–1.10 mm; *breadth*: 0.80–0.85 mm.

Body: (Fig. 1) elongate ovate, strongly convex, with head bent, shiny.

Male: Head, prothorax, antennae, palpi and legs yellow to yellowish brown; elytra, hind margin of pronotum and underside of abdomen dark brown to black. *Head* microsculptured with somewhat transverse striae, bent, strongly convex, triangular in form, wider than long; clypeus small, truncate at margin, labrum with front margin slightly rounded, mandibles well developed, with apical part suddenly sharpened; eyes large, somewhat semicircular, angled in front but broadly rounded behind, inner margins strongly divergent posteriorly, in dorsal view inner margins broadly arcuate, outer ones nearly straight; genal corner pointed; palpi stout (Fig. 2); antennae well defined, 11-segmented, club strong; third segment longer than others, almost twice as long as fourth, fifth as long as fourth, sixth and seventh equal in length, shorter than third and fourth, eighth short and as long as wide (Fig. 3). *Pronotum* strongly transverse, convex, lateral margins broadly lobed, almost invisible from dorsal view, microsculptured with rather transverse striae. *Scutellum* large and wide, hind angle broadly rounded (Fig. 1). *Elytra* surface with finely punctured microsculpture, strongly convex, shorter than combined width (Fig. 1), lateral margins lobed and almost vertical, apical margins broadly rounded; suture line a little convex in lateral view. *Fore tibia* slender (Fig. 4), apex nearly truncate, not dilated, parallel at sides, but gently constricted from one fourth at base.

Genitalia: Basal plate (Fig. 5) broadly flat, emarginate at apex. Penis (Figs. 6, 7) stout, pointed at apex.

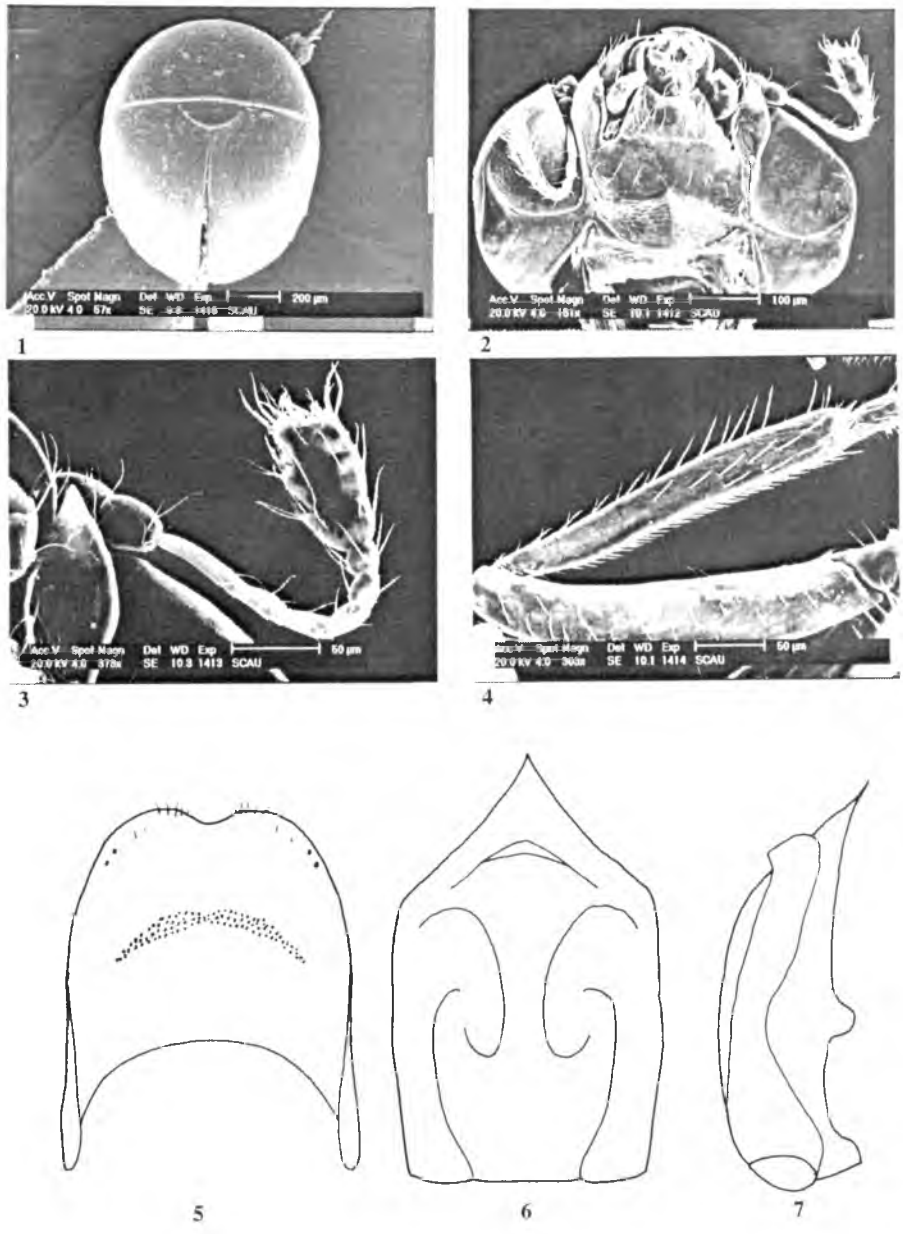
Female: Similar to male, but head and prothorax dark brown to black.

Distribution: Presently known from the type locality.

Holotype: ♂, India: Karnataka: Bangalore, 916 m., vi.2000, reared from *Aleurodicus dispersus* on *Cassia siamea*, Coll. S. Ramani. The holotype is deposited in South China Agricultural University, Guangzhou.

Paratypes: 1 ♂, 2 ♀, same data as holotype; 6 ♂, 2 ♀, vii.2000, other data same as holotype; 2 ♂ and 5 ♀, vi.2001, other data same as holotype. Five paratypes deposited in South China Agricultural University, six in Project Directorate of Biological Control, Bangalore and six in National Pusa Collection, Indian Agricultural Research Institute, New Delhi.

Remarks: This species is similar to *C. binotatus* Grouvelle (Endrödy-Younga, 1968, 1971), but the fore tibia more slender, head and pronotum without metallic shine, basal



FIGURES 1–7: *Cybocephalus indicus* Tian & Ramani, sp. nov.: 1, adult male, dorsal view; 2, head, ventral view; 3, left antenna; 4, fore tibia, ventral view; 5, basal plate, ventral view; 6–7, penis, dorsal and lateral views.

plate broad and emarginate at apex, and penis very different in shape from the latter. The genital structure of *C. indicus* is rather similar to that of *C. aleyrodiphagus* from Australia, but is easily separated from the latter by the following characters: more rounded in shape, scutellum broader, head and pronotum yellow to yellowish brown, and basal plate broader.

Biological notes: *Cybocephalus indicus* sp. nov. is a voracious feeder of the eggs and nymphs of the spiralling whitefly. It was found commonly associated with the whitefly almost throughout the year in Bangalore, especially at high host densities and appears to be an effective predator. Adults and larvae were observed on *Cassia siamea*, a common host on which the whitefly was found in large numbers. Feeding potential studies in the laboratory revealed that during a period of 73 days a female ($n = 2$) fed on 143.5 mature whitefly nymphs at an average of 1.96 per day, while a male ($n = 4$) during a period of 72 days fed on 135.2 mature nymphs at an average of 1.87 per day. Adults live for three months or longer. Its total developmental period for one generation (from egg to adult) in Bangalore is about 27–29 days. The egg stage lasts 4 days. The larval stage, consisting of three instars, lasts 8 days. Pupal stage lasts 16–17 days. A single female laid 112 eggs in 93 days, while one male lived for 90 days. A larval parasitoid, *Cerchysiella* sp. (= *Zeteticontus*) (Hymenoptera: Encyrtidae) was also recorded.

C. indicus appears in nature together with *Encarsia* sp. nr. *meritoria* Gahan and *E. guadeloupae* Viggiani. It has good potential for use as a biological control agent since adults avoid feeding on parasitised whitefly nymphs even when only parasitised nymphs are provided, and can be safely used in conjunction with the parasitoids.

ACKNOWLEDGEMENTS

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An insect based assay to quantify the *Bacillus thuringiensis* insecticidal protein Cry1Ac expressed *in planta*

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ABSTRACT: Transgenic *Bt*-cotton hybrids have been developed by the incorporation of a modified Cry1Ac gene for the management of cotton bollworms. In order to understand the insect control potential of *Bt*-cotton hybrids it is essential to follow the season-long concentrations of Cry1Ac insecticidal protein expressed in various tissues of *Bt*-cotton. The expression profiles provide the basis for comparison and evaluation of various transgenic hybrids. An insect based growth inhibition bioassay has been developed for quantification of Cry1Ac using the larvae of spotted bollworm, *Earias vittella*, as the test insect. The sensitivity of *E. vittella* neonate larvae to low concentrations of Cry1Ac provides a perfect concentration response with respect to percentage of larvae reaching third instar and the dose of Cry1Ac. This assay has been optimized with the purpose of studying the *in planta* expression levels of Cry1Ac in terminal leaf, squares, bolls and seeds of *Bt*-cotton plant.
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KEYWORDS: *Bacillus thuringiensis*, Cry1Ac gene, gene expression

INTRODUCTION

The Cry genes from *Bacillus thuringiensis* nave been introduced into several crops using methods in genetic engineering (Fischhoff *et al.*, 1987; Perlak *et al.*, 1990; Benedict *et al.*, 1993; Schnepf *et al.*, 1998). The *Bt*-insecticidal protein Cry1Ac is one of the most effective *Bt*-toxin against cotton bollworms, *Helicoverpa armigera*, *Earias spp.* and *Pectinophora gossypiella* (Benedict *et al.*, 1996). In India, Maharashtra Hybrids Seed Company (MAHYCO) has developed transgenic *Bt*-cotton hybrids by the incorporation of a modified Cry1Ac gene, a product of Monsanto Technology, for the control of bollworms on cotton. In order to understand the insect control potential of *Bt*-cotton it is essential to follow the season-long concentrations of plant-expressed

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Cry1Ac in various tissues of *Bt*-cotton. The expression levels also serve as a platform for comparing the transgenic hybrids for their insect control efficacy (Greenplate, 1999; Fuchs *et al.*, 1990). This paper describes a quantitative bioassay method for Cry1Ac using the spotted boll worm, *Earias vittella*, as the test insect. This assay can be used for the quantification of *in planta* expressed Cry1Ac in the terminal leaf, square, boll and seeds of *Bt*-cotton.

MATERIALS AND METHODS

Insect culture

A diet-adapted laboratory colony of *E. vittella* was maintained to provide a continuous supply of eggs. Neonates were transferred to culture trays containing semi-synthetic diet. The larvae were maintained on the diet for a week and then transferred to okra for feeding till pupation. The emerging moths were released in oviposition jars and allowed to lay eggs on cloth strips. Eggs were daily harvested and used for bioassays.

Insect diet

A semi-synthetic insect diet was formulated at the Monsanto Research Center, Bangalore for the purpose of conducting bioassay (Table 1). Ninety-six-well microtiter plates were made into test arenas by pipetting 200 μl of warm diet into each well. The diet plates were allowed to surface dry in an aerated incubator at 30 °C for one hour. They were covered with aluminum foil and stored at 4 °C for further use.

Egg-slurry preparation

Two-day-old eggs were surface sterilized and detached from the egg cloth with 0.05% NaOCl solution. The detached eggs were washed 3–4 times with sterile water, debris was removed and the eggs were finally suspended in 0.2% agar. The egg density was so adjusted that a volume of 25 μl (volume dispensed in each well) contained, on an average, 2–3 eggs.

Cry1Ac standard

The source of Cry1Ac was commercial formulation MVP II from Mycogen that contained 19.7% by dry weight of Cry1Ac. (MVP II® bioinsecticide aqueous flowable based on cellcap® encapsulation system, the active ingredient is delta endotoxin of *Bacillus thuringiensis* variety *kurstaki* encapsulated in killed *Pseudomonas fluorescens*).

Bioassay

The Cry1Ac standard was serially diluted in 0.2% agar such that a volume of 50 μl contained Cry1Ac concentrations ranging from 5.55 to 0.484 ng/ml. The insect diet contained in the 96-well microtiter plate was overlaid with 50 μl/well of diluted Cry1Ac. One plate was used for each dose. The plates were air dried in an incubator

TABLE 1. Composition of synthetic diet

Ingredient	Quantity per litre
Fraction A	
Chickpea flour	60 g
Sterile water	400 ml
Fraction B	
Agar	17 g
Sterile water	400 ml
Fraction C	
Antimicrobials	
Methyl parahydroxy benzoate	0.2 g
Sorbic acid	0.2 g
Streptomycin sulphate	0.5 g
Micro-ingredients	
Cystiene	0.1 g
Multivitamin capsules	2 capsules
Wesson's salt	2.5 g
Casein	5.0 g
Cholesterol	0.5 g
Ascorbic acid	2.0 g

at 30 °C for two hours. The eggs of *E. vittella*, suspended in 0.2% agar were dispensed on the diet surface @ 25 μl/well. A thin sheet of Mylar film was heat sealed over the wells and aeration was provided by puncturing the Mylar film with # 0 entomological pins. The plates were incubated at complete darkness, 28 °C and 60% RH in an environmental chanmber. The date of egg hatching was recorded and the assay was rated when more than 90% of the wells in the untreated control plates contained third instar larvae. The concentrations of Cry1Ac, used in the assay, were plotted against the per cent third instars in each treatment and this constituted the **standard curve**. In order to estimate the Cry1Ac content in *Bt*-cotton plant tissues, weighed quantities of tissue powders of lyophilized terminal leaf, square and epicarp of green bolls were appropriately diluted in 0.2% agar solution and 50 μl/well of the dilutions were overlaid on the diet. The assay was then conducted as described for the standard curve.

RESULTS

Concentration-response of Cry1Ac, as observed in *E. vittella* larvae, showed a negative correlation ($r = -0.91$) with respect to percentage reaching third instar and dose of Cry1Ac (Fig. 1). When Cry1Ac was serially diluted from 5.55 to 0.484 ng/ml the response ranged between 1% third instar at the dose of 5.55 ng/ml to nearly 90% larvae reaching larvae reaching third instar at 0.484 ng/ml. The data showed high

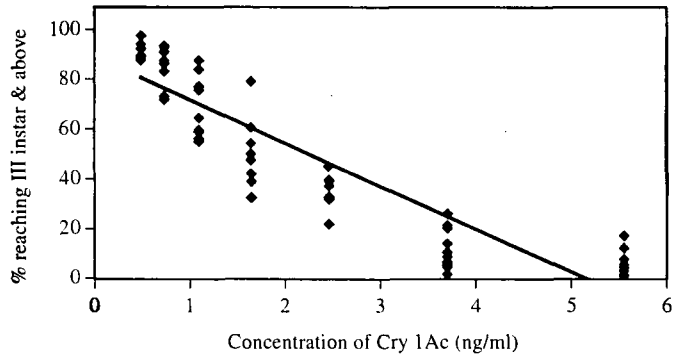

FIGURE 1. Dose response of *Earias vittella* larvae of Cry1Ac (Based on ten bioassays, $r = -0.91$)

reproducibility of the standard curve in subsequent studies. A consolidated standard curve of ten different bioassays is depicted in Fig. 1.

A standard curve is concurrently run whenever a plant tissue sample is to be tested. From the standard curve the amount of Cry1Ac present in the diluted plant samples can be estimated based on their respective values for per cent third instar larvae. These numbers are subsequently corrected to account for the original dilution factors of the plant tissue sample powders. Final estimates of Cry1Ac content in the tissues are expressed as μg of Cry1Ac/g dry weight of plant tissue.

DISCUSSION

The sensitivity of *E. vittella* larvae to sub-lethal levels of Cry1Ac has made possible the development of a reliable quantitative bioassay for the evaluation of transgenic *Bt* cotton hybrids. The sensitivity allowed for extreme dilution of cotton tissue samples and at these levels the secondary plant chemicals, such as, gossypol, would not interfere. The use of lyophilized whole cotton tissue rather than extracts removes the possible questions on extraction efficiency (Fuchs *et al.*, 1990; Greenplate, 1999). This method provides a reliable and standardized method for the evaluation of various *Bt*-cotton hybrids. These studies would also support field performance data and allow evaluation of insect control value of the cotton hybrids. Using this bioassay method season-long monitoring of Cry1Ac levels in the *Bt*-cotton tissues can be achieved.

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Realized and physiological host range of *Ceutorhynchus portulacae* Marshall (Coleoptera: Curculionidae), a natural enemy of *Portulaca oleracae*

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ABSTRACT: *Portulaca oleracae* L is reported as a serious weed in many countries of the world. *Ceutorhynchus portulacae* was identified as a potential biological control agent that could be utilized for its suppression. The present paper reports the host specificity tests of the weevil based on detailed no-choice and multiple choice tests under laboratory conditions, and surveys for their occurrence on non-host plants under natural conditions. © 2003 Association for Advancement of Entomology

KEYWORDS: *Portulaca oleracae*, *Ceutorhynchus portulacae*, host range

INTRODUCTION

A plant of exotic origin and ranking as the ninth world's weed, *Portulaca oleracae* L., is reported to infest about 85 crops in 45 countries of the world (Holm *et al.*, 1977). In the tropical countries including India, it is of considerable importance in many crops like vegetables, vineyards, banana orchards, maize, cotton, groundnut, sorghum, sugarcane, sunflower and rice (Chadha *et al.*, 1995; Mandal, 1990). The weed also acts as alternative host to varied pests and diseases and has allelopathic effects to many crops (Waterhouse, 1993). *Ceutorhynchus portulacae* was identified as a potential indigenous biocontrol agent that could be utilised for the biological suppression of the weed (Ganga Visalakshy and Jayanth, 1997). For any biological control project on weeds, the safety of the biocontrol agent must be taken into consideration before recommending for field releases. Traditionally, this is based on the results of extensive tests of the potential agents host-range by no-choice tests under laboratory conditions (Harris and McEvoy, 1992; Harris and Zwolfer, 1968; Schroeder and Goeden, 1986). However, Balciunas *et al.* (1996) opined that survey of numerous potential hosts

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growing in natural area (in the endemic area) could provide more reliable information of the true host range.

In the present study, adult feeding, oviposition and survival of immature stages of *C. portulacae* was examined under laboratory conditions (physiological host range). In addition, surveys for the occurrence of adults and immature stages of *C. portulacae* on other crop plants where the plant is found to be infesting were also carried out which could help to determine the true host range of the insect.

MATERIALS AND METHODS

Host specificity tests under laboratory conditions (physiological host range)

C. portulacae adults multiplied under laboratory conditions in wooden cages as described by Ganga Visalakshy and Krishnan (2001), were used for the host range tests. Newly emerged adults, 1–2 day old (not exposed to their natural host), were used for the experiments.

The host plants for the screening tests were collected from unsprayed field sites in Bangalore. Wherever the plant material was not available, the plants were grown in glasshouse condition in seed pans (10 cm diameter). Before exposing the host plant to *C. portulacae* the plant was observed under stereobinocular microscope for eggs, larvae and adults of other herbivores which were removed. Apart from this, the leaves damaged by insects or diseases were also not exposed for host range tests.

The test plants selected for screening tests were divided into four categories as recommended by Harris and Zwolfer (1968). (i) Plants related to the host: *Portulacae (portulacae)* that includes *P. tubulifera, P. indica* and *P grandiflora*, cultivated as ornamentals in India. (ii) Plants in which the insect has been recorded. (A survey of literature indicated that *C. portulacae* has been recorded from *P. oleracae* only.) (iii) Plants which have common characters with the host (special attention was given to plants with fleshy leaves or stems, similar to those of *Portulaca oleracae* including *Amaranthus* sp., Coriander, Carrot, Onion, Mentha sp. etc). (iv) The host plants of related insects (*Ceutorhynchus lepi, C. assimilis* are reported as economic pests of cabbage, cauliflower, safflower, etc., in other countries). This category, in addition to the crops mentioned above, had many plants of economic importance belonging to families not otherwise included.

No-choice and multiple choice tests with adults of *C. portulacae* were carried out under laboratory conditions for feeding and oviposition preference. The laboratory temperature ranged between 24–31 °C with 45–75% RH. For the no-choice test, newly emerged adults (1–2 days old) were released into a clean dry plastic jar (11 × 14 cms) having a perforated lid for ventilation. To these jars bouquets of test plants were introduced (the bouquets were made by dipping the cut end of the twigs to a plastic container through a hole on the lid containing water. The twigs were replaced once in 2–3 days. Care was taken to expose apical end of the twigs of about 10 cm length, having young, soft leaves. The experiment was continued till all the exposed adults died. For each test plant, three replicates were run at the rate of 10 adults (5 females and 5 males) per replicate.

Observations were recorded on feeding and oviposition of the exposed adults. Egg laying was recorded and the eggs were kept separately in moist-based petri-plates (10 cm diameter) and observations on hatching, duration of development, survival percentage were noted. In plants where feeding or oviposition was recorded, observations on the leaf area fed by adults, fecundity per female and longevity were made and compared with the natural host.

For multiple choice tests, the plants on which feeding and oviposition had been recorded under no-choice tests were kept in a cage (the wooden cages were 2 × 3 ft. height with glass on three sides and top with a glass door on the front side). The legs of the cages were dipped in ant pans filled with water to prevent entry of ants) along with *P. oleracae*. Observations on the area fed, eggs laid, development and percentage survival of the immature stages were carried out.

Host specificity tests by field survey (true host range)

Surveys for adults and immature stages of *C. portulacae* were made under field conditions to record their host range under field conditions.

RESULTS AND DISCUSSION

Host specificity tests under laboratory conditions (physiological host range)

A total of 68 plants belonging to 36 families were screened for host range tests of *C. portulacae* (Table 1). No feeding was observed on any of the plants, though adults survived for 12 to 35 days. No eggs were recorded on any of the plants exposed, showing that *C. portulacae* is highly host-specific in oviposition.

Host specificity tests by field survey (true host range)

Field surveys carried out on different host plants of 64 species indicated the absence of adults or immature stages in any of the plants. All the plants listed in Table I were surveyed for the insect under field conditions except. *Ipomea batatas, Manihot utilissima, Triticum vulgare* and *Peperomia* sp.

Of the 68 plants screened under laboratory and field conditions, 64 plants were common which allowed the laboratory and field host ranges to be compared, whereby the 'true host range' of *C. portulacae* could be presented. Under laboratory tests the insects were found to be safe for field release as they were host specific to *P. oleracae*. There were no feeding marks as observed on their natural host.

The field surveys carried out on other unrelated hosts especially on crop plants infested by *P. oleracae* further confirm the host specificity of *C. portulacae* under natural conditions. Field host-ranges are considered important in classical biological control projects to determine the true (realised) host range of candidate species, the insects, nematodes or pathogens (Balciunas *et al.*, 1996). Inadequate field data may lead to some potentially beneficial insects being rejected.

During the present study utmost precaution was taken to expose only newly emerged adults not previously exposed to *P. oleracae*. Age of the adult has been reported to be

TABLE 1. List of species tested for feeding and oviposition by *C. portulacae* under laboratory conditions

Amaranthaceae	*Sacharum officinarum* L.	**Rosaceae**
Amaranthus sp. L.	*Sorghum vulgare* L.	*Rosa alba* L.
Amaryliidaceae	*Triticum vulgare Vill*	**Rubiaceae**
Polyanthes tuberosa L.	*Zea mays* L.	*Coffea robusta* L.
Anacardiaceae	**Labiatae**	**Rutaceae**
Mangifera indica L.	*Mentha arvensis* L.	*Citrus medica* L.
Anonaceae	**Leguminosae**	*Murraya exotica* L.
Annona squamosa L.	*Arachis hypogaea Wild*	**Sapotaceae**
Bromeliaceae	*Pisum sativum* L.	*Achras zapota* L.
Ananas comosus Schudt	*Albizzia lebbek*	**Solanaceae**
Caricaceae	*Dolichos lablab* L.	*Capsicum annum* (L.)
Carica papaya L.	*Vigna unguiculata* L.	*Lycopersicum esculentum*
Chenopodiaceae	**Liliaceae**	(Mill)
Beta vulgaris L.	*Allium cepa* L.	*Solanum tuberosum* (L.)
Compositae	**Malvaceae**	*S. melongena* (L.)
Gerbera sp. L.	*Hibiscus sinensis* L.	**Scitaminae**
Solidago sp. Groundel	*Abelmoschus esculentus*	*Musa sp.* L.
Tagetes erecta L.	(L.) *Moench*	**Theaceae**
Helianthus annuus L.	*Gossypium arboreum* L.	*Thea sinensis* Bohea
Convolvulaceae	**Moraceae**	**Umbelliferae**
Ipomea batatas L.	*Morus alba* L.	*Coriandrum sativum* L.
Cruciferae	*Artocarpus heterophyllus*	*Dacus carota* (L.)
Brassica juncea Hk.f & t	*Ficus carica* L.	**Verbenaceae**
B. oleracea L. (*Botrytis* L.)	**Myrtaceae**	*Tectona grandis* L.
B. oleracea (*Capitata* L.)	*Psidium guajava* L.	**Vitaceae**
Raphabus sativas (L.)	**Oleaceae**	*Vitis vinifera* L.
Cucurbitaceae	*Jasminum nudiflorum* L.	**Zingiberaceae**
Cucurbita maxima (Duch)	**Palmaceae**	*Zingiber officinale* Rose
Cucumis sativus (L.)	*Cocos nucifera* L.	*Curcuma longa* L.
Citrullus vulgaris (Thumb)	*Areca catechu*	
Euphorbiaceae	**Piperaceae**	
Ricinus communis L.	*Peperomia* sp. L.	
Codiaeum variegatum	**Portulacacaceae**	
Blume	*Portulaca quadrifida* L.	
Manihot utilissima Crantz	*Portulaca suffrulicosa*	
Graminae	Wright	
Bambusa tulda Roxb	*Portulaca tuberosa* Roxb	
Eleusine coracana Gaerta	**Punicaceae**	
Oryza sativa L.	*Punica granatum* L.	

an important factor which otherwise could alter the results of host specificity tests (Jayanth, 1998). Studies carried out on *Zygogramma bicolorata* a biological control agent of *Parthenium hysterophorus*, indicated that the time taken for initiation of feeding on sunflower was positively correlated with age of the adult exposed. Under no-choice tests, newly emerged adults not exposed to parthenium fed on sunflower

within 1–4 days, while adults 5 and 15 days old took 6 and 15 days, respectively. Adults more than 45 days old did not feed on sunflower. Field observations also indicated that newly emerged adults of *Z. bicolorata* not exposed to parthenium were only capable of feeding on sunflower—an unrelated host of the beetle (Annoymous, 1998).

In addition to age of the adults, the nature of the plant material exposed also played an important role in host range screening. Our studies have indicated that *C. portulacae* prefers the young leaves of *P. oleracae* for feeding and oviposition (Ganga Visalakshy, 2000). Studies carried out on *Bagous hydrilla*, a biocontrol agent of aquatic weed *Hydrilla* sp. has shown significant reduction in feeding and oviposition when old plant material were exposed (Wheeler and Center, 1996). Hence in the present screening fresh twigs containing young leaves of the host plants were only exposed for the feeding and oviposition trials of *C. portulacae*.

The present study reveals that *C. portulacae* is host specific and can be utilised for biological control of *P. oleracae* in other parts of the country. The extensive and safe use of other species of *Ceuthornyhcus* like *C. horridus*, *C. litura*, *C. larvata* and *C. geographicus* and *C. crucifer* against weeds like *Cirscium arvense, Candus nutans* and *Cynoglossum officiale* in many countries (Vayassieres and Wasphere, 1983; Peschken and Beechen, 1973; Forrester, 1993; Prins *et al.*, 1992) further provide evidence for the restricted host range of many species of this taxon.

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Biology of the cigarette beetle, *Lasioderma sericorne* Fabricius (Coleoptera: Anobiidae)

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ABSTRACT: A detailed study on biology of the cigarette beetle, *Lasioderma sericorne* Fabricius was undertaken. Among the biological aspects, morphometry of different stages, mating behaviour, preference of oviposition sites, sex ratio and natural mortality were studied. Females preferred to lay eggs on mid rib furrow of cured tobacco leaves. The ratio of males to females was worked out to be 1 : 1.18. The first instar larvae was the most vulnerable stage for natural mortality. The duration of life cycle depended on ambient temperature and humidity conditions with an average of 55.9 days. © 2003 Association for Advancement of Entomology

KEYWORDS: *Lasioderma sericorne*, mating behaviour, sex ratio, natural mortality

INTRODUCTION

The cigarette beetle, *Lasioderma sericorne* Fabricius is one of the most formidable storage pests of cured tobacco causing severe losses in the tobacco warehouses. The damage is mainly caused by the larvae which feed on cured tobacco leaves, making galleries and the adults make small holes while emerging out from the tobacco and deteriorate the leaf quality. Adequate information on biology of this pest would be useful to take up appropriate control measures and hence biological studies were undertaken in the Department of Entomology, College of Agriculture, Rajendranagar, Hyderabad (A.P.) during 1997. Biology of the cigarette beetle was studied as early as by Runner (1919), Tenhet and Bare (1951), Howe (1957), Kurup and Parkhe (1961), Bhalodia and Chari (1976), Rao (1978), Padmavathamma and Rao (1990). Bhalodia and Chari (1976) observed that 82.74 per cent of eggs were laid on midrib furrows and they recorded a mating period ranging from 15 to 64 minutes. Howe (1957) reported that the first instar larvae was the most vulnerable stage for the natural mortality. The biology of cigarette beetle was little studied in Andhra Pradesh conditions and hence,

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it is necessary to build-up adequate information on the biology of *L. serricorne* which would be useful for taking appropriate control measures in the storage.

MATERIALS AND METHODS

The laboratory culture of *L. serricorne* was maintained under controlled conditions of 29±1 °C temperature and 75 ± 1% relative humidity. The nucleus culture along with infested cured tobacco was initially obtained from a tobacco warehouse and was further maintained by seggregating male/female populations which were subsequently allowed for mating and proliferation. The larvae hatched from these eggs were maintained on artificial diet containing the mixture of wheatflour and dried yeast at the ratio of 2 : 1 in 100 ml beakers as suggested by Chari *et al.* (1995).

The freshly emerged male and female beetles were taken as 20 pairs from the culture and allowed to mate for laying eggs on pieces of folded tobacco. The number of eggs laid per each female were counted and recorded in the morning. The eggs were transferred to petridish with the help of a fine camel brush. When the eggs hatched, larvae were maintained individually in 100 ml beakers containing the mixture of wheatflour and dried yeast. The pupae and adults obtained from these grubs were kept in covered petridishes. The longevity of all the developmental stages was recorded till both the male and female beetles are died in each replicate. The observations on fecundity, hatchability and duration of developmental stages were recorded. The morphometry, using a calibrated ocular micrometer was undertaken for each of the developmental stages. Sex ratio of *L. serricorne* was worked out by collecting pupae randomly from ten samples. Observations on mating behaviour were made by considering 10 pairs of beetles. Studies on preference of oviposition site were made by taking 25 pairs in the laboratory. Eggs laid at different sites on cured tobacco leaves were recorded. Natural mortality of different stages under laboratory conditions was studied by separating 50 individuals at each stage. The data on the observations were subjected to appropriate statistical analysis.

RESULTS AND DISCUSSION

Biology of *L. serricorne*

The eggs of cigarette beetle were observed to be pearly white in colour and oval in shape with a slight swelling in the middle and bluntly rounded. On one end of the chorion blunt spine like projections were observed. The morphometry is presented in Table 1. Four instars of larva were observed. First instar larva was creamy white in colour and possessed few hairs on each segment. They were observed to be extremely active and immediately after hatching, started feeding voraciously on cured tobacco. The second instar larva was also creamy white in colour, with a dense covering of hairs which soon after first moult became erect. The third instar larva was stout bodied, slightly yellowish in colour. They possessed long hairs on abdominal segments. The fully grown fourth instar grub is of 'Scarabaeiform'. The head was darkly sclerotized and the body covered with thick brown hairs. Pupa was creamy white in colour with

TABLE 1. Morphometry of different developmental stages of *L. serricorne*

Developmental stage	Length (mm)			Breadth (mm)			Width of head capsule (mm)		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Egg	0.31	0.45	0.38	0.17	0.26	0.21			
Larval instars									
I	0.48	0.69	0.58	0.14	0.19	0.17	0.11	0.13	0.12
II	0.62	0.77	0.69	0.15	0.24	0.19	0.15	0.18	0.17
III	0.79	1.33	1.06	0.29	0.43	0.36	0.35	0.38	0.36
IV	2.02	2.62	2.32	0.46	0.65	0.56	0.48	0.51	0.49
Pupa (male)	1.73	2.81	2.27	1.04	1.30	1.17			
Pupa (female)	2.43	2.89	2.66	1.14	1.52	1.33			
Adult (male)	2.39	3.09	2.74	1.05	1.52	1.29			
Adult (female)	2.56	3.24	2.89	1.20	1.49	1.34			

Values are means of ten observations.

black compound eyes. The pupa remained inside the cocoon, made of food particles and frass. The sexes were determined at pupal stage by closely observing the genitalia at the caudal end. Genital papillae of female pupa were long, stout and divergent, while in case of male, genital papillae were short, globular and not projecting. Morphometry (Table 1) clearly showed that females were larger than males in length and breadth. The adult were observed to be dark brown in colour and oval in shape with the first thoracic segment bent down. The head was deflexed and obscured from the above, giving the insect a humped appearance. The antennae were serrate. Body was covered with fine hairs. Females were observed to be usually larger than males.

The morphological parameters of the developmental stages of *L. serricorne* observed in the present studies were comparable with the descriptions made by the earlier workers (Runner, 1919; Howe, 1957; Kurup and Parkhe, 1961; Bhalodia and Chari, 1976; Rao, 1978). The variation in the size of developmental stages could be due to the type of food, temperature and humidity encountered during the development.

Mating behaviour

Studies on mating behaviour of male and female beetles were made by observing the freshly emerged adults in the laboratory. It was observed that adults mated within 12 hours after their emergence. The male mounted over the female and extended its abdomen under that of the female to protrude and insert the aedeagus into the vagina of the female and got locked into it. Then the male turned back to have 'tail to tail' position with mating female. The duration of mating period was recorded for ten pairs and was varied from 12 to 75 minutes with an average of 41.3 minutes. It was observed that the female and male individuals mated more than once in their life time. This observation is in close conformity with the finding of Bhalodia and Chari (1976) who recorded a mating period ranging from 15 to 64 minutes.

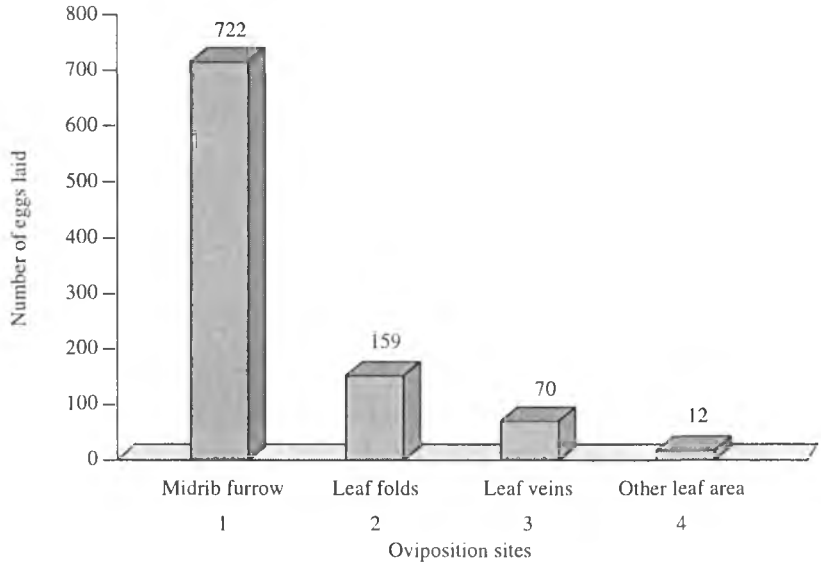

FIGURE 1. Preference for oviposition sites by *L. serricorne*

Preference for oviposition sites on leaf

The observations on the preference for oviposition by 25 pairs of beetles were recorded and the results obtained are presented in Fig. 1. It is evident that out of 968 eggs laid by 25 pairs of cigarette beetle adult, 722, 159, 70 and 12 eggs were laid on mid rib furrow, leaf fold, leaf veins and other areas of tobacco leaf, respectively. In terms of percentage 75.48, 16.42, 7.25 and 1.75 per cent of the eggs were laid on mid rib furrow, leaf folds, leaf veins and other areas of tobacco leaf respectively. Jones (1913) also noticed that the eggs were laid singly on midrib furrow. The preference on mid rib furrow may be attributed to the protection of eggs against the mechanical stresses.

Sex ratio

The sex ratio was worked out by collecting pupae randomly from ten samples. The male and female pupae were distinguished by their genitalia at caudal end. Out of 234 pupae observed at random, 107 were males and 127 were females. The females were usually more in number as compared to the males. The ratio of males to females was worked out to be 1 : 1.18. This is in agreement with Sivik *et al.* (1957); Bhalodia and Chari (1976); Rao (1978) who reported the male to female to sex ratio to be 1 : 1, 1 : 1.33 and 1 : 2 respectively.

Natural mortality

Natural mortality of different stages was recorded and the results obtained are summarized in Table 2. Among different stages of *L. serricorne,* it is evident that the

TABLE 2. Natural mortality of different stages of *L. serricorne*

Stage	Number observed	Number survived	Per cent natural mortality (%)
Egg	50	43	14.00
Larval instars			
I	50	32	36.00
II	50	41	18.00
III	50	46	8.00
IV	50	48	4.00
Pupa	50	47	6.00
Adult	50	50	0.00
S.E.			4.23

per cent natural mortality of first instar larva was the highest (36%) followed by second instar larva (18%) and the eggs (14%) as compared to other development stages. It clearly indicated that the first instar larva was the most vulnerable stage for natural mortality, Where as Rao (1978) reported 53.7 per cent mortality of first instar larva. Further, it was also observed that all the adults were survived for their full term and no natural mortality was observed. Mortality at pupal stage was negligible. This could be due to the protection provided by the pupal case from mechanical and environmental stresses.

Number of generations

In the present investigation, the cigarette beetle completed six generations over a year starting from July 1996 to June 1997 under laboratory conditions. The average duration taken by *L. serricorne* was 55.9 days.

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Short Communication No. ent.28108

Ultrastructure of mouth parts, elytra and tarsus of the banana stem weevil, *Odoiporus longicollis* (Coleoptera: Curculionidae)

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ABSTRACT: Banana stem weevil, *O. longicollis* is the key pest, limits the production of bananas and plantain in India. Scanning Electron Microscopic studies revealed the presence of various types of sensory structures in mouth parts, elytra and tarsus. Banana stem weevil shows a high degree of host plant preference. The ability of weevil to distinguish acceptable host plants may be aided by the presence of array of chemoreceptors on the antennae, mouth parts and tibia.
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KEYWORDS: banana stem weevil, *Odoiporus longicollis*, ultrastructure, sensilla coeloconica

Bananas constitute the fourth staple food of the world. India is the largest producer of bananas in the world. Out of the 40 million tonnes of fruits produced in India, banana occupies number one position with an annual output of 14.0 MT from an area of 400 000 ha. Among the insects pests of banana, the banana corm weevil, *Cosmopolites sordidus* (Ger.) and banana stem weevil, *Odoiporus longicollis* (Oliver.) are the key pests limiting the production and productivity of bananas (Ostmark, 1974).

Literature on occurrence, bionomics and management studies of banana stem weevil is available (Dutt and Maiti, 1971, 1972; Padmanaban and Sundararaju, 1999; Padmanaban *et al.*, 2001, 2002). Ultrastructural details of banana corm weevil has been reported by Nahif *et al.* (1994), but morphological studies on banana stem weevil using scanning electron microscopy is lacking; hence the investigation was undertaken to describe the external morphology of *O. longicollis*. The distribution of sensilla and the olfactory response of antenna were studied using electroantennogram.

The larvae and adults of banana stem weevil, *O. longicollis* were collected from infested gardens and fixed in formalin. The larvae were dehydrated with 40, 60, 80 and

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100 per cent ethanol and then transferred to acetone. Critical point drying was done using L 2001-Firma Demetron. Specimens were sputter coated with a 7 nm thick layer of gold-palladium at 17 °C 75 AM for 60 seconds. Observation and photomicrographs were made with a Cambridge S 2000 Scanning Electron Microscope (SEM).

Adult weevils have substantial layer of variously shaped sensilla in the antennal tip, antennal segment, arolium, proboscis and elytra which are used as sensory receptors of various nature such as chemo-mechano and thermohygroreceptor.

The size of the rostrum and the distribution of sensillae on the rostrum helps in sex determination of banana stem weevil. The rostrum is blunt and short in males, where as in females it is elongated and comparatively slender [Fig. 1A and B]. The sensory structures on the rostrum are blunt and broad. Dorsal side of the rostrum show difference in the distribution of sensory structures. They are slightly on the lateral part of rostrum when compared to the sensilla distributed on the middle rostrum. This is a peg like sensillum called as Sensilla coeloconica and it originates in a depression [Fig. 1C]. This sensilla is similar to the nodulated body sensillum of the 2nd instar larva of *H. postica* (Bland, 1981). This difference in the distribution of rostral sensory structures in males and females are reported as rostral punctuation which are larger in males than females, giving a rough appearance in the former (Dutt and Maiti, 1971). In adults, the mouth lies at the tip of the rostrum below the labrum indicating the elimination of clypeus. The labrum is single, plate like and elongated. The labium is flat and leaf like structure found on the lower side of the mouth. The mandibles have saw like structures on the margins. Below the mandibles, a pair of short maxillae along with maxillary palps are present. The ridge of each maxilla posses paired sensilla. These sensilla are similar to the sensilla basiconica on the apex of the maxillary palp of the larvae of *Hypera postica* (Bland, 1981).

The antenna consists of basal scape, pedical and a flagellum. Chemoreceptive sensilla are located in the antenna. Each segment of antennal club bears three type of sensory organs. The sensilla type II is relatively long and the sensilla type I is a shorter and curvate and the sensilla type III is with pick and ringel [Fig. 2A, C and D]. They are trichoid sensilla. The general arrangement of the various sensilla on the antennal tip is similar to banana corm weevil, *C. sordidus* and consists of three types of sensilla. The sensilla type I is similar to sensilla type I of the banana corm weevil, *C. sordidus* (Nahif *et al.*, 1994). Sensillum trichodea type I of the clover head weevil, *Hypera meles* (Smith *et al.*, 1976) and with the sensillum type II of the pecan weevil, *Curculea caryae* (Hatfield *et al.*, 1976). The sensillum type III is also similar with sensillum trichodea type V of the alfalfa weevil, *Hypera postica* H. (Bland, 1981).

The sensory structures helps in recognising (i) suitable host plant of above five months old (ii) suitable cultivar for oviposition, when more cultivars are present in the same vicinity. Electroantennogram studies indicated considerable difference among the host plant volatiles (Padmanaban *et al.*, 2002). Screening of *Musa* germplasm against banana stem weevil also indicated similar difference in feeding (Padmanaban *et al.*, 2001).

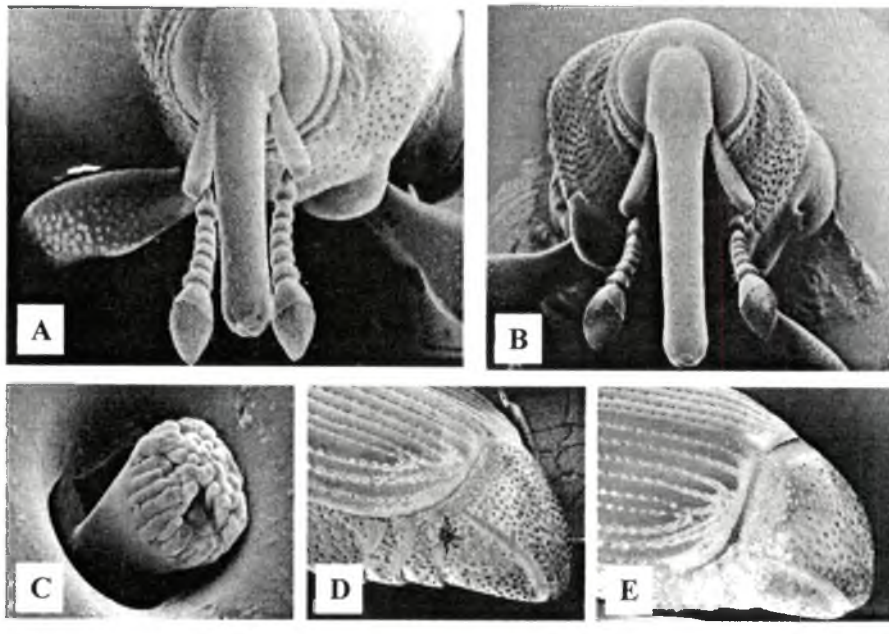

FIGURE 1. SEM micrographs of proboscis and abdomen of *O. longicollis*. A. Proboscis of male, B. Proboscis of female, C. Magnified view of Sensilla on proboscis, D. Abdomen of male, E. Abdomen of female.

The elytra of the adult weevil exhibits sensory structures in a linear fashion. The sensilla are slender elongate and more or less similar to the sensilla present on the female rostrum. This sensillum is called peg like sensillum (sensillum coeloconicum) and originates in a depression. At the tip of the each sensillum, several sensory papillae are found closely adhered like a bud. Coeloconic sensilla with the same external morphology have been described as thermohygroceptors for other insects (Altner and Prillinger, 1980). The adults weevils live in banana sheath, and in the completely decaying stem, where the insect has to maintain the cuticle from water as well as when the surrounding temperature exceeds 25 °C weevil cannot tolerate the temperature and these sensory structures helps the weevil to move into a suitable place. Shukla and Tripathi (1978) reported optimum temperature required for banana stem weevil rearing. Each thoracic segment of banana stem weevil bears a pair of legs and the final parts of these legs are the pretarsus terminated by a pair of claws. The pad like structure of the arolium at the ventral side of the pretarsus, is similar to the glandular hairs of some insects (Lepismatida) excreting an adhesive substance and permitting the insects to walk on the lowerside of objects (Chandler, 1950). The third tarsal segment has elongated fastening hairs with wider distal ends and hollow openings. These hollow structures help in walking and climbing.

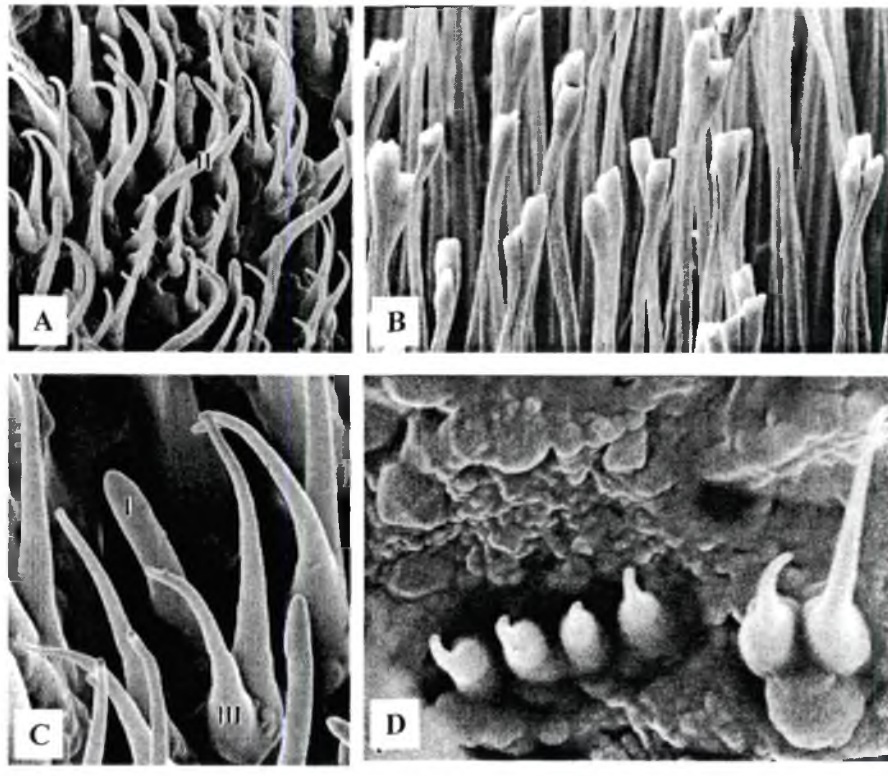

FIGURE 2. SEM micrographs of antenna of adult *O. longicollis*. A. Sensilla type I, B. Fastening hair of pretarsus. C. Sensilla type II with forked structure and sensilla type III with pick and ringel. D. Magnified view of sensilla type II.

Sensory structures are found on the head and body of the larvae. The larval labrum bears elongated thin and elongated thick sensory structures. Maxilla have tooth like structures at the distal ends which helps the larvae in feeding as well as making exit end when the fifth instar grub enters for pupation. Maxillary palp is thick and small at the distal end. Labium has two palps found at the distal lateral end. These sensory structures on the maxillary and labial palps helps the weevil in host selection and feeding. Finger like sensilla are found at the distal end and hair like sensilla are found in between the two labial palps. The large and short sensilla of the body segment is similar to sensilla basiconica and trichodea of the second instar larva of *Hypera postica* (Bland, 1981).

The banana stem weevil shows a high degree of host plant preference. When all the commercial cultivars like Nendran, Robusta, Rasthali, Red banana and Pisang Awak are available in the same vicinity, the weewil recognises and infests only plantain cutlivar *viz*., Nendran. The ability of weevil to distinguish acceptable host plant may

be aided by the presence of an array of sensory chemoreceptors on the antennae, mouth parts, tibia, etc.

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A new species of *Telsimia* Casey (Coleoptera: Coccinellidae) predatory on arecanut scale from Karnataka, India

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ABSTRACT: *Telsimia flavomaculata* sp. n. (Coleoptera: Coccinellidae), predatory on arecanut scale, *Lepidosaphes* sp. (Homoptera: Diaspididae), is described from Karnataka, India. © 2003 Association for Advancement of Entomology

KEYWORDS: *Telsimia flavomaculata*, new species, Coccinellidae, arecanut scale, India

Species of the ladybird beetle genus *Telsimia* Casey (1899) are mostly specialist predators of diaspine scales (Homoptera: Diaspididae). The number of antennal segments in this genus varies from six to seven. All the *Telsimia* species known from India, reviewed by Kapur (1969), have seven-segmented antennae. During surveys for natural enemies of arecanut scales in Karnataka, a new species of *Telsimia* with six-segmented antennae was recorded for the first time from India and is described below.

***Telsimia flavomaculata* Poorani, sp. n. (Figs 1–7)**

Length: 1.25–1.42 mm; width: 1.00–1.12 mm. Body short oval; dorsum strongly convex and densely pubescent, dark pitchy brown to black, with a longitudinal, medially constricted, oblique yellow marking on each elytron (Fig. 1). Ventral side uniformly testaceous to dark brown, except labial palpi, antennae, tibiae and tarsi of legs lighter, yellowish brown.

Head with frons closely and evenly punctate, punctations separated by 2–3 diameters, densely pubescent with anteriorly projecting silvery white hairs; compound eyes large, combined width equal to a little more than half of head width, inner margins slightly incurvate; clypeal margin laterally expanded and shallowly sinuate in middle, completely concealing antennal insertions and mouthparts. Antennae (Fig. 2) 6-segmented, very short, almost completely hidden by expanded clypeal margin; basal segment largest, more than half length of remaining segments; second oblique, subtriangular; third to sixth segments progressively strongly transverse; terminal segment

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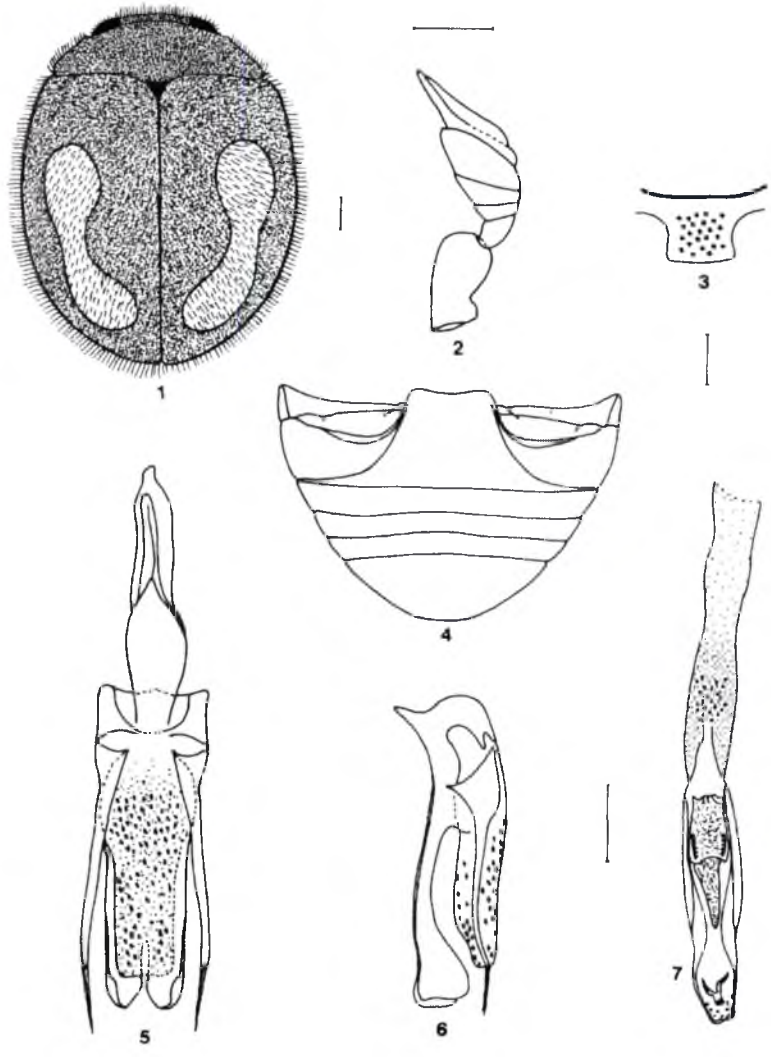

FIGURES 1–7: *Telsimia flavomaculata* sp. n. 1. Adult, dorsal habitus; 2. Antenna; 3. Prosternal process; 4. Abdomen; 5–7. Male genitalia: 5. Aedeagus, ventral view; 6. Aedeagus, lateral view; 7. Sipho (Scale lines = 0.10 mm for Figs. 1, 3–7; 0.05 mm for Fig. 2).

boat-shaped, apically produced into a long, acuminate process, densely and shortly pubescent across, lacking long setae.

Pronotum with anterior margin deeply and trapezoidally excavate, lateral margins nearly straight, finely grooved; anterior and posterior corners acutely and obtusely angulate, respectively; punctations dense and deep, separated by 1–3 diameters;

basal margin medially weakly bisinuate, basal line of pronotum complete. Scutellum minute, triangular, with sides apically strongly narrowed and acuminate.

Elytra with lateral borders narrowly marginate, punctations larger and slightly less dense than those on pronotum, separated by 2–4 diameters; pubescence longer and thicker than that on head and pronotum, slightly decumbent to semi-erect on disk and suberect to erect on sides, dark brown and silvery white hairs intermixed, directed laterad. Prosternal process (Fig. 3) very broad, quadrate, flat, without carinae and coarsely punctate. Abdomen with five visible sternites, postcoxal line on first sternite incomplete (Fig. 4), posterior margin of last visible sternite subtruncate in male and arcuate in female.

Male genitalia highly unusual, median lobe bisected along its entire length in profile (Fig. 6), in ventral view outer lobe medially deeply notched and inner lobe apically truncate (Fig. 5); parameres slender, with 2–3 apical setae; sipho (Fig. 7) lacking anterior capsule, tubular, distally not sclerotized, with two rows of 6–7 stout, heavily sclerotized spines apposed to each other in the middle.

Distribution: India: Currently known from Karnataka.

Material examined: Holotype ♂; India: Karnataka: Padangadi, ~15 km from Dharmasthala, 25.vii.2000, predatory on *Lepidosaphes* sp. on arecanut bunches, Coll. J. Poorani (PDBC). Paratypes: Three, 1♀ with the same data deposited at PDBC; two paratypes with same data, 27.ii.1999, Coll. Sunil Joshi, deposited at The Natural History Museum, London.

Remarks: The elytral pattern and the six-segmented antenna readily separate *T. flavomaculata* from the other species of this region. The terminal segment of the antenna in *T. flavomaculata* is highly modified, boat-shaped with an elongate, acuminate tip and lacks the strong, elongate setae usually found in species with 7-segmented antennae. The male genitalia in Telsimiini are very unusual and in *T. flavomaculata* also, the median lobe of aedeagus is apparently vertically bisected. The elytral pubescence in *T. flavomaculata* is much longer and almost erect, unlike the fine, short pubescence found in the other species of the region.

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Short Communication No. ent.28110

Scanning electronmicroscopic studies on the larval antennal morphology of *Cloeon* sp. and *Baetis* sp. (Ephemeroptera: Baetidae)

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ABSTRACT: The comparative external morphology of the larval antennae of two species of Ephemeroptera, *Cloeon* sp. and *Baetis* sp. examined by Scanning electron microscopy has revealed significant structural differences related to the lentic and lotic nature of the systems they inhabit. © 2003 Association for Advancement of Entomology

KEYWORDS: Antennae, Ephemeroptera, *Cloeon, Baetis.*

The antennae of terrestrial insects play a crucial role in host location and recognition, mating and stabilizing of flight (Gewecke, 1970; Callahan, 1975; Cave and Gaylor, 1987). While the ultrastructure of the antennae of various terrestrial insects have received considerable attention (Cuperus, 1983; Anderson and Hallberg, 1990; Crouau and Crouau-Roy, 1991), studies on the insects of the order Ephemeroptera which are primary consumers in freshwater ecosystems are fewer and their nymphal forms have been largely ignored (Schmidt, 1974; Slifer, 1977; Gupta and Gupta, 1996; Gupta, 1998; Gaino and Rebora, 1998, 1999). In the present study, we describe and compare the external morphology of the larval antennae of *Cloeon* sp., a lentic species, with those of the larvae of *Baetis* sp., a lotic species belonging to the same family (Baetidae) by Scanning Electron Microscopy (SEM) technique.

Larvae of *Cloeon* sp. were collected from the Ward Lake, a small perennial water body in Shillong (Lat. 25 °34′N, Long 90 °52′E, Meghalaya, India) and those of *Baetis* sp. were collected from Umkhrah stream which flows through the outlying areas of Shillong. The specimens were fixed in 2.5% glutaraldehyde in 0.1 M Na-Cacodylate buffer for 2–4 hrs, washed in buffer, post fixed in 1% osmium tetroxide, dehydrated in grades of acetone and finally dried in Critical Point Drying Apparatus. Severed heads of the insects were mounted on brass stubs and coated with gold in fine coat ion sputter JFC 1100. Observations were made in a scanning electron microscope JSM 35CF operated at 15 KV.

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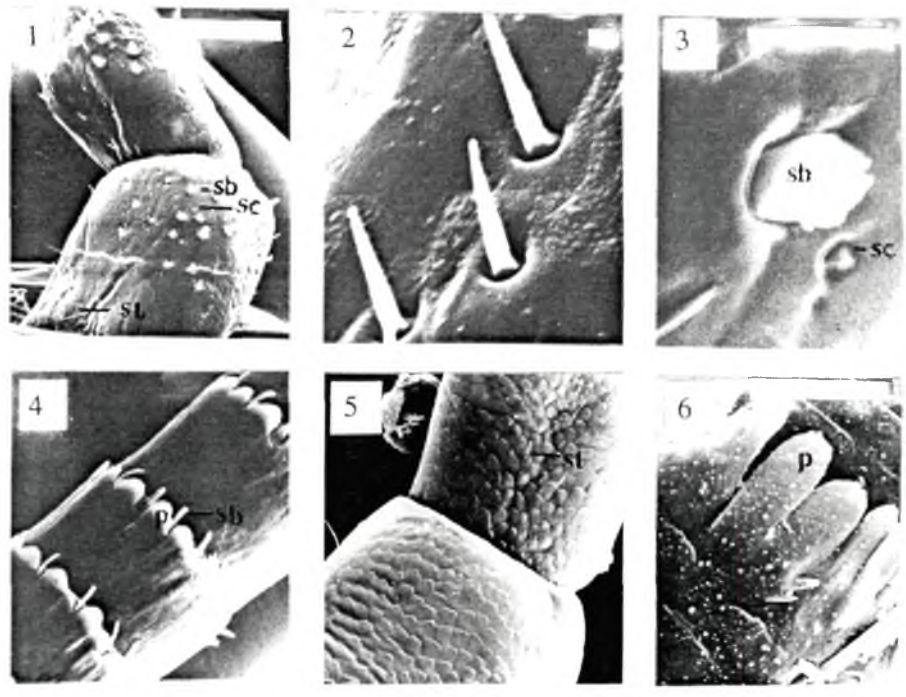
The antennae of both the species are composed of a broad scape, narrow pedicel and a long, slender, flexible flagellum. The scape in Baetis sp. is 160–180 μm broad and 200–240 μm long. Its cuticular surface is smooth with three types of sensilla designated as sensilla 1, 2 and 3. The sensilla type 1 are trichoidea (st) that are arranged in rows of 8–10 on its lateral proximal region forming a hairplate (Fig. 1). These sensilla are stiff, socketed spines with a broad base. Their length ranges from 6.8–7.5 μm and the width at the base from 1.4–1.5 μm. Their socket diameter is around 3 μm (Fig. 2). Sensilla type 2 are sensilla basiconica (sb). They are tongue shaped, and found in clusters of 14-19 in the distal part of the scape (Fig. 3). Their length ranges from 8.9–10 μm and width from 6.4–7 μm while the socket diameter measures around 7–8 μm. The third type of sensilla are sensilla campaniformia (sc) which are found scattered amongst the sensilla basiconica. They are dome shaped with a diameter of 3.5 μm and surrounded by a shallow socket (Fig. 3). The pedicel of *Baetis* is 152–160 μm long and 108–130 μm wide and as on the scape, its cuticular surface is smooth but unlike scape, sensilla trichoidea are found scattered on its distal region without forming a hairplate. The sensilla basiconica occupy the same region as in the scape, but are relatively fewer and sensilla campaniformia are absent on this part. The length of flagellum ranges from 275–300 μm and the number of segments varies from 40–50. The cuticular surface of the segment is devoid of sensilla but the intersegmental membranes have rows of papillae and blunt rod-shaped 7 μm long sensilla basiconica. The length of the papillae ranges from 12.5–13 μm and width ranges from 3.3–4 μm (Fig. 4).

The antennae of *Cloeon* sp. are shorter than those of *Baetis* sp. The scape is around 100 μm broad and 110 μm long, the surface of which is beset with numerous scales. The only sensilla present on the scape are sensilla trichoidea strewn between the scales (Fig. 5). The pedicel is around 65 μm broad and 110 μm long with scales and sensilla trichoidea as on the scape (Fig. 5). The number of flagellar segments varies from 25–34. The surface of the segments is somewhat rough with very few cuticular foldings. Unlike *Baetis* sp., the flagellum of *Cloeon* sp. is devoid of sensilla, although the intersegmental membrances have rows of papillae. They lack sensilla basiconica as found in *Baetis* sp. The papillae are 15–17 μm long and 4 μm wide (Fig. 6).

Sensillar morphology of the antennae coupled with behavioural observations can offer some useful clues as to how these receptors serve the insects, although ultrastructural histology and electrophysiological studies are needed for a better understanding of sensillar function. Nevertheless, by extrapolations of SEM studies we can try to explain the possible roles of the antennal sensilla of these two species of ephemeropteran larvae occupying lentic and lotic systems. From the foregoing descriptions it can be gathered that the antennae of *Baetis* larvae are more diverse through the possession of three types of sensilla *viz.*, sensilla trichoidea (type 1), sensilla basiconica (type 2), and sensilla campaniformia (type 3). In contrast, those of *Cloeon* have sensilla trichoidea only.

The sensilla basiconica on the scape and pedicel of the antenna of *Baetis* sp. are similar to those recorded on the urotergite of an European species of *Baetis*, *viz.*,



FIGURES 1–4: *Baetis* sp. Scape and pedicel, bar 100 μm (Fig. 1); sensilla trichoidea magnified, bar 1 μm (Fig. 2); sensilla basiconica and sensilla campaniformia magnified, bar 10 μm (Fig. 3); flagellum, bar 10 μm (Fig. 4).

FIGURES 5–6: *Cloeon* sp. Scape and pedicel, bar 10 μm (Fig. 5); flagellum, bar 10 μm (Fig. 6). st—Sensilla trichoidea; sb—Sensilla basiconica; sc—Sensilla campaniformia; p—Papilla.

Baetis rhodani, on the basis of their flat shape, well-defined socket and apical pore. On the other hand, sensilla basiconica on the flagellum of *Baetis* sp. resemble the 'flat tipped sensilla' found in *Baetis rhodani* (Gaino and Rebora, 1998, 1999). Sensilla campaniformia is however absent on the flagellum and found scattered among the sensilla basiconica on the scape and pedicel. The mechanical function of sensilla campaniformia in insects is well-established. They are shown to respond to lateral rotation, bending or compression forces (Zill and Moran, 1981; Grunert and Gnatzy, 1989; Gnatzy *et al.*, 1987; Kapoor, 1991) and most are located in the joint and bordering areas (Gaino and Rebora, 1999). Furthermore, sensilla campaniformia can sense the movement of flagellum over the pedicel and monitor stress imposed by water flow on each flagellar segment (Kapoor, 1991). The presence of sensilla campaniformia mostly in the anterior portion of the scape and pedicel of *Baetis* larvae indicates their possible role as proprioceptors (Schmidt and Smith, 1987; Gaino and Rebora, 1998) giving mechanical strength to the antenna, for making darting movements against the current, and also for preventing dislodgement from the stones

in running water. Sensilla basiconica on the other hand being a specialized structure provide gustatory inputs to the larvae for the reception of food resource information (Gaino and Rebora, 1998). Hence it can be surmised that the three types of sensilla on the antenna help them monitor their movements in the turbulent stream and the absence of scales provides a smooth cuticular surface offering least resistance against flowing water. In contrast, the poor sensory diversity of *Cloeon* larvae reflects a much simpler life in lentic water. Our observations on the absence of flat tipped sensilla in *Cloeon* larvae is also consistent with that made by Gaino and Rebora (1999). Thus larvae of this species possessing only sensilla trichoidea depend solely on tactile information for foraging and defense. Hence sensillar diversification in shape and arrangement on the antennae of the two species studied clearly reflects their different habitats and modes of living.

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Short Communication No. ent.28111

Feeding toxicity of acetamiprid 20 SP to silkworm, *Bombyx mori* L.

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ABSTRACT: The feeding toxicity of acetamiprid 20 SP to silkworm was tested in laboratory experiment by leaf disc method at different test doses *viz*., 0.001, 0.002, 0.003 and 0.004 per cent. It was found that all the doses tested were less toxic to silkworm. © 2003 Association for Advancement of Entomology

KEYWORDS: acetamiprid, feeding toxicity

Mulberry (*Morus* spp.) is infested by several pests. These pests affect the growth of mulberry and cause considerable damage to the plant and loss in leaf yield. The insecticides applied for the control of mulberry pests have greater impact on silkworm. Synthetic chemicals have problem of residue in mulberry leaves which inturn affect sensitive silkworm. To overcome this problem, safe waiting period should be followed for leaf harvest (Yohoyama, 1962). Safe period for utilization of insecticide sprayed leaves for silkworm rearing was found to vary from 10–15 days (Ullal and Narasimhamma, 1981; Munnivenkattappa *et al*., 1989). Acetamiprid is a new generation pesticide, which has an excellent control of many pests of crops. The studies on the effect of acetamiprid on silkworm are lacking. Hence this investigation was taken up to evaluate the safetyness to silkworm.

The recommended test doses of acetamiprid *viz*., 0.001, 0.002, 0.003 and 0.004 per cent were prepared. Chlorpyrifos 20 EC (0.004%), quinalphos 25 EC (0.005%) and endosulfan 35 EC (0.007%) were included for comparison. Leaf discs of approximately 6 cm diameter were cut from well grown mulberry. The leaf discs were thoroughly washed with water and later dipped in the liquid concentrations of insecticides for 20 seconds and then shade dried. The treated leaf discs were transferred to plastic containers. In each container, 20 pre starved (for half an hour) silkworm larvae (third instar of F_1 generation) were placed and each treatment was

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TABLE 1. Feeding toxicity of Acetamiprid 20 SP to silkworm, *Bombyx mori* L.

Treatment	Concentration	Corrected per cent mortality HAT		
		24	48	72
Acetamiprid 20 SP	0.001	11.6	15.3	22.0
Acetamiprid 20 SP	0.002	13.3	20.0	26.6
Acetamiprid 20 SP	0.003	16.6	25.0	28.0
Acetamiprid 20 SP	0.004	20.0	33.3	35.0
Chlorpyrifos 20 EC	0.004	60.0	100.0	100.0
Quinalphos 25 EC	0.005	63.0	100.0	100.0
Endosulfan 35 EC	0.007	68.0	100.0	100.0

HAT—Hours after treatment.

replicated thrice. The control was treated with water. Mortality counts were taken at 24 hrs after treatment and subsequent counts were taken at 12 hrs interval upto three days. The per cent mortality was corrected using Abbots formula (Abbot, 1925).

Acetamiprid 0.004 per cent caused 35 per cent mortality whereas all other doses *viz.*, 0.001, 0.002 and 0.003 per cent were less toxic causing mortality less than 30 per cent at three days after treatment (Table 1). But the insecticides *viz.*, chlorpyrifos (0.004%), quinalphos (0.005%) and endosulfan (0.007%) were extremely toxic caused cent per cent mortality even at 48 hrs after the treatment. The data indicated that all the concentrations of acetamiprid tested (0.001, 0.002, 0.003 and 0.004 per cent) against *Bombyx mori* were less toxic whereas the other insecticides were more toxic. Dhahivabeevi (1989) reported that feeding silkworm with dichlorvos 0.2 per cent, FORS 2.5 per cent and monocrotophos 0.2 per cent sprayed leaves required a safety period of 4, 9 and 14 days respectively. Similar findings were also reported by Sengupta *et al.* (1990) and Ali (1995). From this study it was concluded that acetamiprid 20 SP was safer to silkworm and it can be used for the control of mulberry pests.

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OBITUARY

Professor M. S. Mani

(1908–2003)

Prof. Mahadeva Subramania Mani (M. S. Mani) was born on 2nd March, 1908 at Thanjavur, Tamil Nadu. In 1928 he joined the Government College, Coimbatore for his Intermediate, after his School Final Examination from K. S. High School, Thanjavur. After his Intermediate, he joined the Madras Medical College but could not continue his studies due to financial constraints. He went to Calcutta in search of a suitable job in 1933 and got a job as a tutor cum demonstrator in Physics on a part-time basis at Bangabasi College, Sealdah. At the same time, he worked at the Indian Museum of the Zoological Survey of India, Calcutta as an honorary research student. It was only after a while he got a small job at the Zoological Survey of India in the early 1930's. He then worked on plant galls and gall insects and became interested in Chalcidoidea. He obtained M.A. Degree by research in 1937 from the University of Madras on the basis of his research papers in Entomology (the only candidate to be so honoured). Since then he worked for a period in the Indian Agricultural Research Institute, Delhi with Prof. M. S. Pruthi and published his work 'Biological Notes on the Chalcidoidea' as Pruthi and Mani. In 1945 he joined St. John's College, Agra as a teacher and in 1947, obtained D.Sc. Degree of Agra University for his work on galls and gall insects of India. In 1950 Dr. Mani established the famous school of Entomology at the well reputed St. John's College, Agra. It was here at the School of Entomology that he initiated research on various aspects of entomology and several students obtained doctorate degrees under his guidance. From the School of Entomology, he led many scientific expeditions to Himalayas to study High Altitude Entomology and published a book by that name. These and later studies by him helped to establish his concepts on the origin and distribution of fauna and flora of Indian subcontinent. These aspects were well described in his classical work 'Biogeography in India'. In 1956 he was invited by the Central Ministry, New Delhi to join the Zoological Survey of India where he served as Deputy Director and later as Officiating Director. In 1968 he returned to School of Entomology where he worked for some years as Emeritus Professor. Later he continued in that position at the Regional station of Zoological Survey of India,

Chennai and afterwards at the Botany Department of the Presidency College, Chennai.

Prof. Mani led an Indian delegation of Zoologists to USSR in 1963. He represented India in MAB (Man and Biosphere) committee in Alpine and Arctic Ecology in Lillehammer, Norway in 1972. He was a visiting Professor of Entomology at Tribhuvan University, Kathmandu, Nepal in 1971. Gordon Edwards of Colorado named him the Dean of High Altitude Entomology in 1971. He was awarded the Scientist of the Year award by Presidency College in 2000. The Ministry of Environment and Forests, Government of India awarded him E. K. Janakiammal Award for Taxonomy, 2001, which carried a crash award of Rs. 1 lakh. Prof. Mani is survived by his wife, Mrs. Rajalakshmi Mani, two sons and a daughter and several grand children and great grand children.

Professor Mani was an affectionate and highly respected teacher. He always worked hard and it is not surprising that he could publish over 35 books (which included research monographs also) and more than 300 research papers. Personally Prof. Mani has always been very kind towards me. In 1968 I had the good fortune to hear some of his lectures when I was a student at St. John's College, Agra. I remember, later in 1979, when I requested him the Chalcididae specimens he had with him, for my studies as loan, he sent me several boxes of specimens, with an affectionate letter saying that I need not return them. He was glad to write a forward for my book on Parasitic Hymenoptera and Biological Control in 2001. Prof. Mani had a wide range of interests from Insect Biogeography, High Altitude Entomology, Cecidology, besides Taxonomy and Ecology. His contribution to science makes him an outstanding biologist with few equals. I consider myself fortunate to have been associated with such a great professor.

Prof. T. C. Narendran

OBITUARY

Dr. P. K. Sen-Sarma

(1929–2002)

It is with great sorrow that we announce the demise of Dr. P. K. Sen-Sarma, one of the eminent termitologists of our country and former Director, Biological Research, Forest Research Institute, Dehra Dun, on 29 July 2002. His contributions which span over four decades as a researcher in forest entomology, educationalist and an administrator are well recognised.

Dr. Sen-Sarma was born on 1 April 1928 in a modest, respectable family and had his early education in Khulna, now in Bangladesh. After the partition in 1947, his family moved to Kolkatta. He graduated in Zoology (Hons.) in 1949 obtained M.Sc. (Zoology) in 1951 and Ph.D. in 1964, all from the Calcutta University. All through he had a brilliant academic record and was a recipient of gold medal for Masters degree.

Dr. Sen-Sarma's professional career started at the Forest Research Institute, Dehra Dun, where he worked along with M. L. Roonwal, a doyen in the field of forest entomology. Later, Dr. Sen-Sarma became the Head of Entomology and the Director, Biological Research at FRI, Dehra Dun. During his career he also headed the Forest Research Centres at Bangalore and Ranchi. He was the Principal Investigator of a PL 480 project "Studies on wood destroying termites in relation to natural termite resistance in timbers". He also taught forest entomology to the I.F.S. probationers of the Indian Forest College. His enthusiasm did not wane even after superannuation in 1987 as evinced by the responsibilities which he took over in later years such a Dean, Faculty of Forestry, Birsa Agricultural University, Ranchi; Emeritus Scientist, North-Eastern Hill University, Shillong; Visiting Scientist at Presidency College and at Kurukshethra University of Kurukshethra. His perseverance and profound faith probably helped him to continue his scientific pursuit in later years in spite of his ill health. He was a special speaker at IX IUSSI meeting at Colorado, USA. He was among the founders of the Indian chapter of IUSSI.

Dr. Sen-Sarma was a Fellow of National Academy of Sciences, India; Indian Academy of Sciences; Indian Academy of Wood Sciences and National Academy of Agricultural Scientists. He was also member of a large number of scientific societies

and was the Sectional President (Zoology, Entomology and Fisheries) of the Indian Science Congress for the year 1987–88. He has travelled widely both within India and abroad. He has visited several Universities/Research Institutions in Europe and USA.

During the long span of over 40 years of productive research career. Dr. Sen-Sarma contributed immensely in the fields of taxonomy, biology, ecology and control of termites. He published more than 200 scientific papers, which include several monographs. He also authored five books.

My professional contacts with Dr. Sen-Sarma started in 1970 and he was largely responsible for kindling my interest in termite research. After his term of work from Birsa Agricultural University in 1991, he used to write to me frequently till the last month before his death in July 2002. The last sentence of his last letter sounded to me like a farewell note. He wrote "Kindly accept my thanks for all the favours that you have done to me all these years. With regards and good wishes".

In the passing away of Dr. P. K. Sen-Sarma, India lost another great termitologist. We express our heartfelt condolence to the family and friends of Dr. Sen-Sarma.

R. V. Varma

INFORMATION TO CONTRIBUTORS

Scope: ENTOMON will accept original articles (but not reviews) arising from studies on insects, arachnids and myriapods. Papers dealing only with insecticide residue analysis and breeding plants for insect resistance, however, will not be considered. Papers on morphology, anatomy and histology (based on light microscopy, SEM or TEM) are acceptable only if they are related to physiology, behaviour or taxonomy.

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Keywords should be limited to four or five; they will be used for compiling the index.

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3rd GLOBAL MEET ON PARASITIC DISEASES

BANGALORE UNIVERSITY, BANGALORE, INDIA

NOVEMBER 25–29, 2003

ANNOUNCEMENT AND CALL FOR ABSTRACT

The Bangalore University, The Indian Society for Parasitology and the Society for Applied Genetics are organizing the 3rd Global Meet on Parasitic Diseases from 25–29 November 2003 at Bangalore University, Bangalore, Karnataka, India. The Meet will focus on 'Emerging Parasitic Diseases and their Control' and will cover the following topics.

Taxonomy, Life cycle and Parasitology; Molecular and Cell biology; Genetics and Biotechnology; Diagnosis and Clinical aspects; Morphology and ultra structure; Pathogenesis and Epidemiology; Immunology; Immune response, Vaccines; Drugs, Chemotherapy and Drug resistance; Vector Biology and Vector control; Biochemistry, Physiology and Nutrition; Parasite cultivation, Animal models and colonization; Host–parasite relationship; Ecology and Environmental Parasitology; Environmental control and Management; Biodiversity of Parasite and Vectors; Impact of Urbanization and Parasitic diseases; Techniques; Zoonosis; Sociology and Economics; Information, Education and Communication; Modeling and Diseases control; Public Health; Biotechnological tools in the control of both vectors and parasites; and Plant and Soil nematodes.

Interested persons are invited to submit abstracts latest by **15 September 2003**.

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